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WMO SATELLITE REPORT - APPLICATION OF SATELLITE TECHNOLOGY: ANNUAL PROGRESS REPORT 1991

Note by the Secretariat

The World Meteorological Organization (WMO) has submitted the attached annual progress report on the application of satellite technology 1/ for the information of the Committee on the Peaceful Uses of Outer Space. The report is available in English only.

Notes

1/ In view of the limited number of copies received, the report is distributed to the members of the Committee only.

WORLD METEOROLOGICAL ORGANIZATION

WMO SATELLITE REPORTS

APPLICATION OF SATELLITE TECHNOLOGY

ANNUAL PROGRESS REPORT

1991

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INTRODUCTION

The purpose of this publication is to make Members aware of the state of development in satellite applications, as well as the operational uses of satellite data, derived products and services in the meteorological and hydrological services in different countries.

This Annual Satellite Report has several parts including the operational status of various satellite systems, a synopsis of related satellite training events and conferences held during 1991 and Progress Reports from WMO Members and EUMETSAT. The Progress Reports contain a review of the applications of satellite technology within three functional areas:

(1) Remote sensing of spectral radiation which can be converted into measurements for meteorological and operational hydrological applications (this includes the data and the derived products such as atmospheric soundings, sea surface temperature, satellite cloud track wind, etc.);

(2) Collection of data from in-situ sensors (commonly referred to as the data collection system such as Service-Argos on the NOAA polar-orbiting satellites); and

(3) Transmission of satellite data through a direct broadcast mode (APT and High Resolution Picture Transmission (HRPT) on polar-orbiting satellites; WEFAX, Low Resolution Facsimile (LRFAX), and high resolution (S-VISSR) to Primary Data Utilization Stations (PDUS) and Secondary Data Utilization Stations (SDUS) on geostationary meteorological satellites).

Progress reports from WMO Members and EUMETSAT have the following major subdivisions:

PART I	A summary of the major highlights of research applications and operational changes;
PART II	Major research and development and applications of satellite data, derived products and services;
PART III	A description of techniques development and applications of satellite data, derived products and services;
PART IV	System for satellite applications in operational use in 1991
PART V	Plans for future operational systems for satellite applications to meteorology and operational hydrology
PART VI	Validation and verification of satellite data and derived products used in operations
PART VII	Other items (references, publications and names of scientists in charge, etc.)

The present report, the seventh in the series, contains contributions received in response to the request made in WMO circular letter S/MS/PUB of 26 May 1992. In that letter, Members were requested to provide input for this report and where possible on diskette to allow electronic editing. This has allowed a more uniform display of Members' activities.

EXECUTIVE SUMMARY

This set of country reports for 1991 from 30 Members and EUMETSAT shows a continued development of satellite data applications in the various fields of meteorology and operational hydrology.

Detailed information can be found in the individual Progress Reports covering a wide range of applications. Several recurring uses and applications appear in many of the reports.

In the area of monitoring phenomena which have devastating impacts, such as tropical cyclones, severe meso-scale storms, floods and forest fires, several progress reports contain important and innovative descriptions of new capabilities. For example, Canada reports the use of artificial intelligence techniques for evaluating the development-potential factors in explosive cyclogensis (see Canada, Meteorology paragraph 2.1). China noted that in the summer of 1991, the Anhui and Jiangsu Provinces of Southeast China suffered severe flooding and that SMA/SMC used data from FY-1B and the NOAA satellites to monitor continuously the flooding (see China paragraph 3.1).

With regard to the derivation of the basic physical parameters of both the atmosphere, such as wind, temperature and moisture, and the surface, such as sea surface temperature, vegetation, ice and snow cover, sea ice, ocean states and albedo, there is a richness in the ongoing research and its application. Argentina reports that since 1990, a monthly report concerning the evolution of crops and pastures in the Pampa Humeda zone is issued using the Vegetation Index from the NOAA radiometer (see Argentina paragraph 3.3). Argentina has also implemented a volcanic ash alert service to detect and track volcanic ash for general aviation avoidance (see Argentina paragraph 3.6). Australia has developed an operational system for producing cloud track winds on the Australian Regional McIdas (ARM) (see Australia paragraph 2.4). Canada has developed and tested algorithms for snow water equivalent, snow extent and snow state using the SSM/I as a major component of the Use of a Cyrospheric System to Monitor Global Change in Canada (see Canada, Meteorology paragraph 2.10). Ethiopia is studying the use of vegetation index while surveying crop, pasture and forest areas (see Ethiopia paragraph 2.2). EUMETSAT is continuing their development efforts to derive cloud track winds using the METEOSAT Water Vapour channels and ECMWF is presently validating the water vapour winds (see EUMETSAT Part II). France produces fine scale (2 km resolution) sea surface temperature maps to meet the French Navy requirements (see France paragraph II-6) and uses clustering algorithms to identify 20 different NDVI temporal behaviours over western Europe using NOAA AVHRR data (see France paragraph II-8). The Drought Monitoring Centre (DMC) and the Department of Resource Surveying and Remote Sensing (DRSRS) both use NDVI images produced from AVHRR data (see Kenya paragraph 4.1). Singapore has developed image enhancement techniques using GMS and NOAA data to delineate areas enveloped by thick haze and volcanic ash (see Singapore paragraph 3.2). The United States of America has put into effect their Volcanic Hazards Alert Plan which utilizes data from the NOAA polar-orbiting satellites, GOES and GMS to determine plume altitudes and ash cloud movement. The United States of America also noted the operational production of 8 km and 1.1 km sea surface temperature maps based on NOAA AVHRR data (see United States of America Part I).

Convective rainfall, monthly river run-off and water balance are successfully determined by using more sophisticated satellite retrieval techniques for hydrological applications. Canada is evaluating two distributed hydrological modelling systems for flood forecasting and other applications (see Canada, Operational Hydrology paragraph 2.1). Finland uses both NOAA AVHRR and METEOSAT high resolution data to estimate rainy areas and instantaneous rainfall (see Finland paragraph 3.1). Germany has developed a mathematical hydrological model which allows the estimation of monthly runoff values based on the information obtained from satellite imagery (see Germany paragraph 2.5).

These parameters are also being widely applied to diagnostics, nowcasting, numerical weather prediction and climate studies. The Deutscher Wetterdienst is participating in the Global Precipitation Climatology Project (GPCP) by providing the Global Precipitation Climatology Centre (see Germany paragraph 2.9).

The number of meteorological satellite ground stations continue to increase and some are being upgraded to obtain the high resolution satellite direct broadcast data. There is also a continued increase in workstation development for satellite data applications. Canada notes that work is underway on a new-generation workstation called METWORKSII to be used by operational forecasters in all AES forecast centres (see Canada, Meteorology paragraph 3.1). Hong Kong is developing a computer workstation for off-line satellite data processing in collaboration with a university in Hong Kong (see Hong Kong paragraph 3). The United States of America has developed an Interactive Digital Image Display and Analysis System (IDIDAS) which is being used to support NOAA's Coastal Ocean Program (see United States of America Part IV).

Satellite data are handled in a digital format at the high resolution stations, most of which carry on some operations to derive quantitative information from the radiances. This information is being increasingly used as input data for numerical weather-prediction models. Atmospheric sounding data and cloud-wind vectors are input in the objective analysis scheme. Humidity estimates are made using satellite image data. The improvement of sounding retrievals has been a particular focus of many of the research efforts found in the Progress Reports. Several progress reports note ongoing research in cloud classification. The Democratic People's Republic of Korea described their ongoing research efforts for sounding retrievals based on Eyr's method (1989) (see Democratic People's Republic of Korea paragraph 2.1). Finland has designed a sounding processing system using their CRAY-XMP using the ITPP software from Wisconsin (see Finland paragraph 2.). The Finnish Meteorological Institute and the Helsinki University of Technology have a project to develop an automated method to classify clouds from AVHRR imagery using neural network classifiers (see Finland paragraph 3.2). France has developed an operational cloud classification method whereby up to 16 cloud types can be identified (see France paragraph II-3). Germany receives TOVS directly and inverts the radiances to obtain vertical temperature profiles by means of the ITPP-3. They are conducting research to use forecasts from the mesoscale "Europa-Modell" as a first guess in the retrieval process (see Germany paragraph 2.1). The Netherlands uses the 3I retrieval technique and the derived 1000-500 hPa thickness maps are used as a monitoring tool (see The Netherlands paragraph 2.1). The Philippines note that they intend to establish a real-time TOVS processing capability for operational use (see Philippines paragraph 5.1). The United Kingdom has work underway to increase the effectiveness of soundings for operational use for local area use (Local Area Sounding System (LASS)) and for global use (Global Sounding System (GLOSS)) (see United Kingdom paragraph 3.5). The United States of America has developed an interactive retrieval system whereby the data assimilation and forecast functions of the NWP system are linked directly with the satellite temperature/moisture retrieval system (see United States of America Part III).

Satellite-based telecommunication continues to increase for operational use among WMO Members. Satellite data collection provides a valuable source of in-situ observation data from isolated meteorological and hydrological stations and from ships, buoys and aircraft. Such data from remote regions also offer ground truth information concerning various meteorological and hydrological parameters for validating information derived from satellite remote sensing. Australia has used the GMS DCP capability for about twenty AWSs, while reports from about 150 southern-hemisphere drifting buoys, including some AWSs, were relayed via the Service Argos system on NOAA satellites (see Australia paragraph 1.2). Canada has continued the use of DCPs from buoys in the Arctic and Pacific Oceans which are formatted in DRIBU code and placed on the GTS (see Canada, Meteorology paragraph 4.3). The Water Survey of Canada (WSC) has equipped about 900 gauging stations with DCPs which transmit environmental data via the GOES satellite (see Canada, Operation Hydrology paragraph 4.1). Colombia installed 42 DCPs to transmit hrdrometeorological information via the GOES satellite to stations located in Bogata and Cali (see Colombia paragraph 1.2). Ethiopia installed nine DCPs nation wide for the collection of meteorological data from stations via METEOSAT (see Ethiopia paragraph 1.3). Germany has added 57 DCPs in the eastern parts of Germany for pollution monitoring at the request of the Federal Environmental Agency (see Germany paragraph 4.4). The United States of America has increased the capabilities of the GOES DCS with the addition of the DCS Automated Processing System (DAPS) (see United States of America Part IV).

Of particular interest is the use of satellite data types from new research satellites. The European Space Agency launched their Earth Remote Sensing Satellite (ERS-1) on 17 July 1991. ERS-1 has several instruments which have the potential to provide new operational information in the fields of meteorology and operational hydrology. Several Progress Reports report on the use of such data types. The Netherlands note that impact studies of ERS-1 data assimilated operationally into KNMI's High Resolution Limited Area Model (HIRLAM) are being conducted and that the assimilation of ERS-1 scatterometer winds has had a positive impact on analyses over the North Sea (see The Netherlands paragraph 2.3). Sweden used data from ERS-1 in their operational satellite system called PROSAT (Processing System for Meteorological Satellite Data) and in particular the SAR for sea ice analysis (see Sweden paragraph 1.2). The United Kingdom indicates that their development efforts with algorithms for ERS-1 scatterometer winds has produced analyses of higher quality than those currently obtained from ships (see United Kingdom paragraph 2.5). The United Kingdom also indicates that they are exploiting the data from NASA's UARS satellite (see United Kingdom paragraph 2.7).

Education and Training is a very important area to WMO Members. Many Progress Reports indicate that a continuing efforts is occurring to improve the level of understanding and use of satellite data in meteorology and operational hydrology. The United Kingdom has continued its efforts on the 500-page reference manual containing guidance for operational meteorological forecasters on interpreting satellite and radar images (see United Kingdom paragraph 3.2).

The bibliography at the end of each chapter should be an excellent reference for those Members seeking a more indepth explanation.

EDUCATION AND TRAINING
CONFERENCES, SEMINAR AND WORKSHOPS DURING 1991

WMO regional training seminar on the use of environmental satellites data in meteorological applications for RA II and RA V, Beijing, China, October 1991.

Sixth International TOVS Study Conference, Airlie, Virginia, 1-6 May 1991.

5th conference on physical measurements and spectral Signatures in Teledetection. Courchevel. January 1991

Infrared and Millimetre Wave Conference. Lausanne August 1991.

A Workshop on cloud motion winds 17-19 September 1991, Washington, D.C. sponsored by EUMETSAT, NOAA and WMO.

STATUS REPORT FOR SATELLITE SYSTEMS

At the tenth session of the EC Panel of Experts/CBS Working Group on Satellites held in Geneva 16-20 March 1992, experts from organizations operating environmental satellites made presentations on the status of their satellites as follows:

EUMETSAT Status Report

1. Meteosat Operational Programme

METEOSAT-2 was removed from geostationary orbit on 2 December 1991, in conformity with international agreements, and lifted into an orbit with a perigee of 334 Km and an apogee of 524 Km above the geostationary orbit. The transmitters were switched off on 6 December 1991.

METEOSAT-3 continues to support the ADC mission, and is currently located close to 50° west.

METEOSAT-4 supports routine operations. Radiometer decontaminations were carried out from 18 to 20 December 1991 and 10 to 12 February 1992. Images, provided by METEOSAT-5, were relayed through METEOSAT-4 during these periods. The development of software to correct the effects of METEOSAT-5 image anomaly continue in ESOC. Images were taken from this satellite during the periods of decontamination of the METEOSAT-4 radiometer and updated software was tested. MIEC products derived from these images were not disseminated during the first METEOSAT-4 decontamination period because of unacceptable quality. Revised software was tested during the 2nd period. Acceptance testing of the two possible radiometers of MOP-3 will commence shortly following completion of black-body modifications and lens fit checks. MOP-3 integration will commence in September 1992, for a planned launch in September 1993.

ADC imagery continues to be used for GOES/METEOSAT Relay (GMR). At the request of users, a full disk IR image is now transmitted for the LXI format. An LX format containing IR and VIS data is currently being developed and will be tested in the near future.

ADC operations continue to schedule. From 15 November 1991 normal ranging of the satellite was possible, thus removing the weekly 2-day breaks in WEFAX service from Lannion. Favourable comments on ADC continue from USA and elsewhere. At the request of NOAA/NESDIS, State and Country boundaries have been added to ADC WEFAX formats.

An operational MDD products dissemination schedule has been agreed and was implemented in mid-February 1992. Planning for implementation of MDD broadcast encryption continues. Bracknell and Rome have been equipped with encryption equipment. Decryption key units are being manufactured and are being distributed to authorised MDD user stations. An encryption key centre has been installed in EUMETSAT HQ. An implementation plan for image data encryption was requested from Council.

2. METEOSAT Transition Programme

The operational phase of the METEOSAT Transition Programme covers the period 1995 - 2000.

The manufacturing activities of the MTP satellite are proceeding on schedule. Negotiations have been concluded with the prime contractor (Aerospatiale) and all the sub-contractors. Direct negotiations with ESA are now addressing the EUMETSAT/ESA contract.

Procurement activities on the ground segment are ongoing. These include contracts for the Core Facility, operations, and negotiations for the Ground Station. The product requirements and the user requirements for the Meteorological Products Extraction Facility (MPEF) are defined and a Working Group has been set up to review these documents. The Ground Segment will be operational in 1995.

3. METEOSAT Second Generation

It is planned to implement a METEOSAT Second Generation (MSG) Programme in two phases: a pre-operational and an operational phase. The pre-operational phase would be a joint effort with ESA who would develop the MSG satellite under an ESA Programme funded in part by EUMETSAT. The operational phase would be under sole responsibility of EUMETSAT with support from ESA.

ESA Phase A studies on the MSG Imager have been completed in early March 1992. Results are being reviewed by EUMETSAT. The two MSG System Phase A studies funded by ESA have initiated in early February, for a completion in December 1992.

EUMETSAT is now initiating Phase A studies relevant to the definition of the Ground Segment. Additional studies concerning the definition of future meteorological products to be extracted from MSG have also been initiated.

4. EUMETSAT Polar Systems

A EUMETSAT contribution in meteorological observation from polar orbiting satellites is confirmed. The EUMETSAT Council has forwarded a favourable answer to the ESA offer for a flight opportunity in the frame of the ESA Earth Observation Programme in polar orbit and has requested the EUMETSAT Secretariat to negotiate with ESA the terms of this participation. In addition the Secretariat was requested to prepare relevant EUMETSAT Polar Systems (EPS) programme proposals compatible with the requirement for continuity of observation in the "morning" polar orbit.

Ongoing EUMETSAT activities are aimed at progressing the instrument and Ground Segment studies, defining the overall mission and preparing for these Programme.

The following studies are progressing (in accordance with EUMETSAT's competitive procurement policy, each study is being conducted by two independent contractors):

- Phase B studies for the Microwave Humidity Sounder (MHS), (end in June 1992)
- Phase B studies for the Meteorological Communications Package, (end in September 1992)
- Pre-phase A ground segment studies, (started in February 1992).

The two sets of Phase B studies are progressing on schedule and allow for a possible Phase C/D start in 1993.

5. Other EUMETSAT activities

EUMETSAT participates actively in a wide range of activities relevant to International Committees and Working Groups such as CGMS, CEOS, ICWG, EOS-ICWG, and those set up by WMO.

An increasing effort is devoted to address the use and quality of products extracted from Meteorological satellites through support to Education and Training activities, publication of information material concerning present and potential applications from satellite data, and support to International Scientific Conferences. In this respect, and as an example, EUMETSAT participates the CGMS initiative concerning improvement of wind fields derived from cloud motions and the joint WMO, NOAA, JMA, and EUMETSAT co-sponsored series of Workshops.

Japan Meteorological Agency Status Report

Product Plan of GMS-5

Geostationary Meteorological Satellite - 5 (GMS-5), the successor to the current operational GMS-4, is under development and fabrication, and is scheduled to be launched in early 1994. GMS-5 will have additional observation spectral bands beyond the current satellite as summarized in the following:

Channel	GMS-4	GMS-5
Visible	0.50 to 0.75μm	0.55 to 0.90 μm
Water Vapor	None	6.5 to 7.0 μm
Thermal Infrared	10.5 to 12.5μm	10.5 to 11.5 μm 11.5 to 12.5 μm

Remarks: GMS-5 will have an experimental search and rescue communication equipment to relay distress signals.

It is planned that modification of the ground communication system and replacement of computer system in the Meteorological Satellite Center (MSC) will be performed before the GMS-5 launch, and also various products of MSC (see Table) will be improved using the above mentioned sensors and disseminated to users via GMS-5 or GTS. Major products are described as follows:

1. Stretched VISSR

All VISSR data will be disseminated to MDUS users via GMS-5 and the dissemination format will be the same as the current one with only slight modifications, i.e. water vapor and split window data will be added to the current S-VISSR.

2. WEFAX

The dissemination format is planned to be the same as the current one. On the broadcast schedule, sectorized water vapor images will be broadcasted twice a day in addition to the current schedule.

3. Satellite Wind

The satellite winds at the middle level of the atmosphere will be newly derived using water vapor images. The low level and high level cloud motion winds will continue to be derived, and we plan to improve the accuracy of the height assignment through the use of water vapor images. Those data will be disseminated via the GTS.

4. Sea Surface Temperature

Sea surface temperatures will be estimated with better accuracy than the current method since the amount of water vapor, the main source of SST error, can be estimated from the temperature deference of the split window channel data.

5. Cloud Amount

Cloud amount will continue to be derived by using one of the channels from the split windows. We plan to slightly improve them by using finer vertical profiles from numerical weather forecast.

6. Equivalent Black Body Temperature

One channel of the split window will be used in the processing. The processing method will not be changed.

7. Upper Air Humidity

This data will be newly made from the combination of water vapor data and one channel data from the split window.

8. Precipitable Water

This data will be newly made from both channel data from the split window.

9. Typhoon Analysis

The center location of typhoons and the intensity of typhoons will continue to be estimated by operators.

10. WCRP data

ISCCP and GPCP data will continue to be archived.

GMS-5 Product List (planned)

Product Name		Frequency	Horizontal Resolution	Region
Broadcast				
Stretched VISSR	VIS	Hourly	1.25km at SSP	Full Disk
	WV	ditto	5.0 km at SSP	ditto
	IR1	ditto	ditto	ditto
	IR2	ditto	ditto	ditto
WEFAX				
Polar	IR1	Hourly	1710 X 800 Pixel	Far East Area
	VIS	Hourly	ditto	ditto
Four Sectorized	IR1	3 Hourly	ditto	4 sect
Rectified Disk	WV1	12 hourly	ditto	ditto
Cloud Motion Wind				
low level		6 hourly	1.0 Lat./Lon.	50N-50S,90E-170W
middle level		ditto	ditto	ditto
high level		ditto	ditto	ditto
Sea Surface Temperature		5 days	0.5 Lat./Lon.	50N-50S,90E-170W
Upper Air Humidity		6 hourly	ditto	ditto
Precipitable Water		6 hourly	ditto	ditto
Cloud Amount		5 days	ditto	60N-60S,80E-160W
Equivalent Black Body Temperature		3 hourly	ditto	ditto
Typhoon Analysis				
Location of Center		3 hourly	-	North of eq.
Intensity		6 hourly	-	100-180E

Remarks: SSP = Sub-Satellite Point

Russian Federation
Committee for Hydrometeorology
and
Monitoring of Environment (ROSCOMGIDROMET) Status Report

The current environmental satellite system which ROSCOMGIDROMET operates includes:

- meteorological satellites of "METEOR-2" and "METEOR-3" types;
- oceanographic satellites of "OKEAN" type;
- operational land resources satellite of " RESURS" type;
- ground receiving, processing and distribution complex including a Main centre in Moscow and Regional centres in Novosibirsk and Khabarovsk.

There are now 6 satellites in orbit and a brief summary of the status of each spacecraft is given below.

"METEOR-3" Series

"METEOR-3" No. 6 (launched 24.01.91), and "METEOR-3" No.5 (launched 15.08.91) continued to be principal operational satellites providing the Main and Regional centres at least twice daily with global data on the distribution of clouds, snow and ice in VIS and IR bands, atmospheric temperature sounding data, cloud top heights and sea-surface temperature, radiation fluxes data in the near outer space. The functioning of these spacecraft is generally normal apart from failure of sounding mission (irregular noise in signal) on board of "METEOR-3" No.5. It should be also mentioned that NASA's Total Ozone Mapping Spectrometer (TOMS) is flown on "METEOR-3" No.5 providing global ozone levels in the Earth's atmosphere. Data continued to be downlinked normally to receiving stations at Wallops Flight Facility and Moscow, with data analysis performed by NASA and ROSCOMGIDROMET. This is the first flight of NASA instruments on a Russian spacecraft.

"METEOR-2" Series

"METEOR-2" No. 19 (launched 28.06.90) and "METEOR-2" No. 20 (launched 28.09.90) are also continuing to be operational satellites, experiencing, however, anomalies with sounding missions (noisy downlinked data, both spacecraft) and IR imagery ("M-2" No.19). It is expected that these spacecraft will remain operational for several more months and, depending on their performance, will be put on the stand-by mode. Therefore, the "METEOR-2" system, which came into operational use in 1975, will be fully replaced by the "METEOR-3" system.

"OKEAN" Series

"OKEAN" no. 6 (launched 04.06.91) has started experiencing its missions degradation since September 1991. Except for data collection missions, and imagery missions (medium resolution scanners, VIS band) which have been normal, the satellite has an anomaly in side-looking radar and scanning microwave radiometer performance. It is planned to launch in the nearest future, a subsequent spacecraft of this type. The overall programme will continue with at least two more satellites of the "OKEAN" series.

"RESURS" Series

"RESURS" No. 2 (or "KOSMOS"-1939) launched 20.04.88 has remained the operational satellite. Imagery in all three spectral channels (high resolution scanner MSU-E) and in five channels (medium resolution scanner MSU-S) being normally good quality. However, due to some problems with energy supply, imagery missions are performed with certain constraints in time. The "RESURS" programme will continue at least until 1995.

"METEOR" Series

ROSCOMGIDROMET intends to continue meteorological satellite service with "METEOR-3" series of satellites. In order to ensure a continuation of the Earth radiation budget measurements from space through the 1990s, France, Germany and Russia are developing a Scanning Radiometer for Radiation Balance (ScaRaB) to be flown on "METEOR-3" No.7 in the third quarter of 1993. France is in charge of the development of a scanning head; Russia will develop the on-board calibration sources, the mechanical interface to the spacecraft and the thermal control; Germany will participate in the calibration and certification of the on-board sources. The decision to launch a series of ScaRaB, at a rate of one per year, up to at least 1996 is currently under study.

At present, ROSCOMGIDROMET has contracted with industry to develop a new generation of meteorological satellites of "METEOR-3M" series. In addition to sounding missions, 3-channel visible and IR radiometer with ground resolution 700m x 1400m (VIS), 3km x 3km (IR) and swath width of 3100km will be flown. Data transmissions will be made at S-band (1670-1770 MHz) in three modes at the rate of 14.4 Mbit/sec, 960 Kbit/sec and 64 Kbit/sec. The last two modes will be worldwide direct transmission. The expected date for implementation of this system is 1995.

GOMS

The current phase of the programme includes the manufacture of GOMS No.1, procurement of the second spacecraft and the implementation of the ground segment. Because of budget constraints started last year, most of the industrial contracts were negotiated with delay and, therefore, it has not been possible to keep the original schedule. However, the integration of this satellite is continuing and the work has also progressed in implementation of the ground segment. It is scheduled to finish integration tests and arrange for shipping the GOMS No.1 to the launch site by the end of this year.

INSAT-I SYSTEM Status Report

1. Status of INSAT-ID

INSAT-ID, the last satellite in the present INSAT-I series of satellites was launched successfully on 12 June 1990 from Cape Kennedy, USA and declared operational on 17 July 1990. This had been placed at 83 degrees East position and functions as a replacement of the previously operational INSAT-IB satellite at 74 degrees East. All operations of Earth imaging have, therefore, been shifted from INSAT-IB to INSAT-ID and at present it is the operational satellite of INSAT-I series.

2. Operational Use of INSAT-ID for Meteorological Application

INSAT-ID Meteorological satellite data are being processed on an operational basis at the Meteorological Data Utilization Centre (MDUC) located in the IMD, New Delhi. The Very High Resolution Radiometer (VHRR) data are processed at MDUC to provide the following products:

a) Earth Cloud Cover Imageries in the Visible and Infrared bands:

Normally, 11 full-Earth disc scans are obtained daily as a routine. Additional ingests are also commanded during important weather situations. Based on the analysis of these cloud pictures, regular bulletins are sent to the users.

b) Cloud Motion Vectors (CMVs):

Cloud Motion Vectors giving a measure of winds in the upper levels of the atmosphere are being derived at 03 and 06 UTC using ingests taken in VIS band at successive half-hourly intervals. Winds are being derived over the Arabian Sea, Bay of Bengal and the Indian Ocean areas and are being transmitted over National Meteorological Telecommunication Network for utilization within India and over the GTS of WMO for international utilization once per day based on winds derived at 06 UTC.

c) Sea-Surface Temperature (SST):

The data obtained from VHRR are being used for derivation of Sea Surface Temperature (SST) for the Bay of Bengal, Arabia Sea and part of the Indian Ocean on an experimental basis.

d) Estimation of Precipitation and Outgoing Long-Wave Radiation:

Estimation of Quantitative Precipitation Index is made using 3 hourly INSAT-ID data. Such precipitation estimates are averaged over large areas (2.5 degrees square Lat/Long) over a week or month. Similarly, outgoing long wave radiation (OLR) weekly and monthly averages are being computed over 2.5 degrees (Lat/Long) square areas.

e) The cloud imagery data obtained from INSAT-ID are being transmitted every three hours in analog facsimile mode to the 20 Secondary Data Utilization Centres (SDUCs) located at various important forecasting offices of the Department in the country through dedicated communication links.

3. INSAT-ID also provides the following Communications for Meteorological Services:

i) A scheme for dissemination of cyclone warnings directly to the coastal areas likely to be affected called Disaster Warning System (DWS), is in operation since January 1986. The performance of this scheme is found to be very effective and satisfactory when the cyclonic storms affected the coastal areas on several occasions from 1987 to 1991. Under the scheme 50 more DWS receivers will be deployed in the near future in addition to the existing 100 DWS receivers, for the reception of cyclone warnings through INSAT. Thus the total number of 150 DWS receivers will cover the coastal regions of the Indian sub-continent.

In this scheme, cyclone warning messages originating from the Area Cyclone Warning Centre, are transmitted to INSAT from the nearest Earth Station. The S-band transponder of INSAT receives and relays back these signals over the Indian Territory for direct reception by DWS receivers. In this scheme, the transmitted signals selectively address only those specific set of DWS receivers for which the cyclone warnings are meant.

ii) Scheme for Meteorological Data Dissemination (MDD) through INSAT, using the S-band transponder of INSAT-ID is under implementation.

With this scheme, it will be possible to receive processed meteorological data (INSAT images in analogue form, meteorological charts and alphanumeric observational data) at locations within the zone of telecommunications of INSAT. Under this scheme, 23 stations will be installed within India in a phased manner. Ten stations have been commissioned thus far. Very recently, a station for receiving these data was established at Male, as part of a bilateral agreement between India and the Maldives.

REPORT ON THE FUTURE SATELLITE SYSTEM

INSAT-II System:

The INSAT programme will be continued through the 1990s by launching the 2nd generation INSAT Satellites (INSAT-II). The first satellite of INSAT-II series will be launched in mid-1992 on an Ariane Launch vehicle of ESA. The first two satellites of INSAT-II series are being fabricated by the Indian Space Research Organization (ISRO) satellite centre, Bangalore, to meet the requirements of various user agencies. INSAT-II satellites will replace the currently operational INSAT-I satellite series in a phased manner. Critical Design Review (CDR) of INSAT-II satellite has been completed and the first satellite of the programme (INSAT-IIA) is now in an advanced stage of testing before its shipment to the launch site in mid-1992. Like INSAT-I, INSAT-II is also a multi-purpose, three axis stabilized geostationary satellite system to provide services for Meteorology, Telecommunications and Television and consists of the following meteorological payloads:

a) Very High Resolution Radiometer (VHRR)

The function of the VHRR is to image the Earth's cloud cover in visible and IR channels. The resolution at the sub-satellite point will be 2.0 kms (visible) and 8 kms (IR). The VHRR will image the Earth's cloud cover over the Indian and adjoining land and sea areas. The scan mechanism will have the capability for full Earth scan with 20 degrees (N-S) x 20 degrees (E-W) and sector scan will have 20 degrees (E-W) x 4.5 degrees (N-S). Normally, VHRR will scan 14 degrees (N-S) x 20 degrees (E-W) field of view for most of the day to day operations.

b) Data Relay Transponder (DRT)

The DRT on INSAT-II will be like that on INSAT-I, for collecting of meteorological data from Data Collection Platforms (DPCs) located over remote and inaccessible areas.

INSAT-II METEOROLOGICAL GROUND SEGMENT

For utilization of meteorological capability of INSAT-II satellite, a suitable ground segment is being established in the premises of the Meteorological Department, Lodi Road, New Delhi for direct reception of INSAT-II meteorological data. A new INSAT-II Meteorological Data Processing System (IMDPS) with improved capabilities for processing of satellite meteorological data and derivation of products is being commissioned shortly. It will consist of eight VAX-3400 series of computer and will also have capabilities of ingesting conventional meteorological data and processing of TOVS data from US polar-orbiting satellites.

The meteorological satellite programme of China

The meteorological satellite programme of China consists of two major parts: Polar orbiting and geostationary series named FY-1 and FY-2, respectively. The main objective of this programme is to establish a comprehensive operational meteorological satellite system before the end of this century. The Ministry of Aerospace takes responsibility for the space segment, while the State Meteorological Administration is in charge of the ground segment.

Polar orbiting meteorological satellite FY-1

In 1969, with the increasing awareness of the importance of space meteorology, China decided to enter this field. After investigation for 8 years, the first project, FY-1, which is a polar orbiting meteorological satellite, was initiated in 1977.

FY-1 is a hexahedron of 1.4 m by 1.4 m by 1.2 m with a weight of 750 kg. The two solar cell arrays mounted on both sides of the main body make the total length 8.6 m. The attitude of the satellite is three-axis stabilized with a precision of less than 1°. FY-1 operates in a sun-synchronous orbit at an altitude of 901 km with an orbital period of 102.86 minutes. The inclination is 98.9° and the eccentricity is less than 0.005.

The main payload of FY-1 is an Advanced Very High Resolution Radiometer (AVHRR) with a 1.2 mrad field-of-view (FOV) and 1.1 km resolution at the sub-satellite point (SSP). The radiometer operates in five spectral bands:

- 0.58-0.68 μm visible band for daytime cloud and surface images.
- 0.725-1.1 μm near-infrared band for daytime cloud images and water, ice, snow, and vegetation observations.
- 0.48-0.53 μm and 0.53-0.58 μm visible bands for ocean color images.
- 10.5-12.5 μm infrared band for day and night cloud images, surface observation, and sea surface temperature.

The basic data of FY-1 are disseminated in three modes: HRPT, APT and Delayed Picture Transmission (DPT). For HRPT and APT, direct readout services are provided during its lifetime with data formats compatible with the NOAA satellites. During the same period, FY-1 orbital predictions are transmitted via the Global Telecommunications System (GTS). HRPT/APT data dissemination channel characteristics are as follows in Table 1.

Table 1

Carrier frequency	Code rate (subcarrier frequency)	Modulation mode	Power
HRPT 1695.5 or 1704.5 MHz	0.6654 Mbps	PCM/PSK	5W
APT 137.935 or 137.795 MHz	2.4 KHz	AM/FM	8W

DPT data are cloud images from selected areas the world over for domestic use only.

The ground segment of FY-1 comprises three ground stations, which are located at Beijing, Guangzhou, and Urumqi, and a Data Processing Centre (DPC) at

Beijing equipped with three IBM 4381 PO3 computers. This system is capable of receiving and processing data from NOAA satellites. The data received at the ground stations are relayed in real-time to the DPC for processing, distribution, and archiving. Products derived from the DPC include: cloud image mosaics in a variety of projections; meteorological parameters such as sea surface temperature and cloud top temperature; and environmental parameters such as vegetation index, snow cover, sea ice, etc. All raw data and products are archived on digital tapes. Images are broadcast via TV and dedicated circuits for field operations. Users can get products through on-line PC terminals or by receiving non-real-time data.

The first Chinese experimental meteorological satellite, FY-1A was launched on September 7, 1988. Although it did not last the expected lifetime, the system design and equipment performance were examined. There were two major problems with FY-1A: attitude control, which caused the satellite to go out of control after 39 days; and water vapour contamination on the IR detector, which was responsible for IR signal loss. After 2 years of study and improvements, the second satellite, FY-1B, was launched on September 3, 1990. The status of the two flights is summarized as follows:

Both the satellites, which were launched by Long March 4 vehicles, had excellent orbital elements.

The AVHRR, which was the major payload on board the satellites, obtained cloud images with very high resolution, and terrestrial surface characteristics with 1-km scale were clearly distinguishable. The IR images, which were not successful on FY-1A were greatly improved for FY-1B.

Satellite attitude, which caused FY-1A to go out of control, also was obviously improved, but it did not yet reach the expected precision and lifetime even for FY-1B. It still needs to be improved.

Future geostationary meteorological satellite FY-2

After the first flight of FY-1, the geostationary satellite project FY-2 was formally put into schedule.

FY-2 is a spin-stabilized satellite with a mechanically despun antenna. The diameter of the spacecraft is 210 cm. The length is 454 cm with an apogee motor and 310 cm on station. The weight is 1200 kg and 520 kg with and without the apogee motor respectively. FY-2 is expected to be located at 105-108°E, and to have a lifetime of more than 3 years. The attitude and orbit control performance are designed as follows:

Spin speed (on station)	100±1 rpm
Station keeping	1°N-S, 0.5°E-W
Attitude maintaining	±0.5°
Attitude determination	0.1°
Attitude stability	3.5 μr over 0.6 sec 3.5 μr over 30 min
Antenna pointing accuracy	±0.5°

FY-2 has four major functions: Earth imaging, data dissemination, data collection, and environmental monitoring.

The major role payload for Earth imaging is a 3-channel Visible Infrared Spin Scan Radiometer (VISSR). It takes 32 full-disk observations every day with characteristics: as shown in Table 2.

The basic data are disseminated in three modes: stretched VISSR (S.V.), low resolution facsimile (LR-FAX), and S-band transponder (S-WEFAX). S.V. and LR-FAX are compatible with the Geostationary Meteorological Satellite (GMS) of Japan. S-WEFAX uses a separate transponder. It is capable of working 24 hours a day for disseminating satellite and numerical products to local weather offices.

The data collection system collects data from a wide variety of platforms. These data are relayed to FY-2 on up to 133 frequency channels (33 international and 100 domestic) for meteorology, hydrology, oceanography, and other purposes. FY-2 also carries a space environment monitor for monitoring of space particles.

The ground segment of FY-2 consists of a Command and Data Acquisition Station (CDAS), a Satellite Operational Control Center (SOCC), a Data Processing Center (DPC), middle- and small-scale data-utilization stations, and a ground communication system. Products derived from the DPC include: a variety of cloud image projections, wind-vector derivation, sea surface temperature, cloud amount, and cloud top temperature, water vapour content, and a composite minimum brightness chart for snow cover monitoring.

FY-2 is now in the stage of preliminary test, and the ground segment is under construction. First launch of FY-2 is expected in the mid-1990's.

In order to support the World Meteorological Organization's World Weather Watch Programme, China will make the basic observational results from Chinese meteorological satellites available, share these data with the meteorological community, and is willing to carry out international co-operation in this field.

TABLE 2

Channel	Visible	Infrared	Water Vapour
Wavelength	0.5-105 μm	10.5-12.5 μm	5.7-7.1 μm
Resolution at SSP	1.25 km	5 km	5 km
FOV	35 μr	140 μr	140 μr
Scanning lines/frame	2500 x 4	2500	2500
Detectors	Si photo-diode	HgCdTe	HgCdTe
Noise performance	S/N > 6.5 (albedo = 2.5%) S/N > 43 (albedo = 95%)	NE δ T= 0.5-0.6K at 300 K	NE δ T=1K at 360 K Delta= δ Greater than = >

NOAA Status Report

1. Geostationary Operational Program

A. Present spacecraft status

GOES-2 was launched on June 16, 1977. The VISSR imager was declared unusable on January 16, 1979. The Stretched VISSR Atmospheric Sounder Transmissions and Weather Facsimile (WEFAX) is done on a best effort basis.

GOES-3 was launched on June 16, 197. The VISSR imager became unusable in 1981 due to cumulative encoder lamp failures. The Peacesat Transponder remains operational.

GOES-6 was launched on April 28, 1983. The VAS Filter wheel central circuitry failed on December 23, 1983. The VISSR/VAS declared unusable January 21, 1989, which was the final encoder lamp failure. Digital METEOSAT is being retransmitted through GOES-6 and NOAA DCS-WEFAX and the Space Environmental Monitor (SEM) remain operational.

GOES-7 was launched on February 26, 1987. The High Energy Proton and Alpha-Particle Detector failed since launch. VISSR/VAS, SEM-SAR, Data Collection Platform Interrogation and Report, and East WEFAX broadcast remain operational.

B. Atlantic Data Coverage (ADC) Support

The excellent cooperation between NOAA and EUMETSAT continues in this endeavor. METEOSAT-3 is expected to be moved from 50 degrees West to a position over the United States by January 1993. The ground equipment to support METEOSAT-3 operations from a more westerly position is under development and on schedule.

C. GOES I-M

GOES-I Status

GOES-I launch will be no earlier than late 1993, with GOES-J a year later. The serial number 2 instruments now under test were scheduled to be integrated into the GOES-I spacecraft for launch. NOAA obtained the services of MIT's Lincoln Laboratory to make recommendations regarding preparations for GOES-I launch. Lincoln laboratory recommended that the serial number 2 instruments be tested thoroughly, but not integrated into the GOES-I satellite for launch. Due to the extensive testing already done on these instruments the decision was made to modify the serial number three instruments to correct the problems found on the serial number two instruments. The modified serial number three instruments will then be flown on GOES-I. The serial number two instruments will be refurbished later for flight on a later GOES satellite. Vibration testing is complete and thermal vacuum testing of the serial number two instruments is now being completed after which the instruments will be integrated into the GOES-I spacecraft for additional testing.

Launch Schedule

The following GOES launches are scheduled: 1993:GOES-I; 1994:GOES-J; 1996:GOES-K; 1999:GOES-L; and 2001:GOES-M. GOES I-M will be launched using a commercial launch service vehicle (Atlas Centaur).

GOES I-M Improved Capabilities

GOES I-M will have earth location accuracy of -4 km (currently 10 km). IR resolution will be 4 km which will improve tracking and detection of severe storms and flash floods (currently 8 km). The sounder resolution will be 8 km with seven additional channels (currently 14 km). GOES I-M will have simultaneous imaging and sounding (currently not simultaneous). Finally, GOES I-M can take a "small picture" view of a severe storm every 5 minutes (currently limited "small picture" repetitive viewing available).

2. Polar Orbiting Operational Program

A. Present spacecraft status

NOAA-9 is the afternoon satellite. It is in a standby mode, with only ozone data collected from the Solar Backscatter Ultra-Violet Radiometer (SBUV). NOAA-10 is the morning satellite and is in a standby mode. NOAA-11 was launched in September 1988. It is the operational afternoon satellite. NOAA-12 is the primary operational morning satellite (since September 1991) that was launched in May 1991.

B. Future Spacecraft Plans

NOAA-I will be an afternoon satellite scheduled for launch later this year. The following future launches are scheduled: NOAA-J (AM) in 1993; NOAA-K (PM) in 1995; NOAA-L (AM) in 1996; and NOAA-M (PM) in 1997.

C. Long Term

NOAA O,P,Q were under a phase A study that ended in January 1992. The request for proposal (RFP) is currently under discussion with NASA with a release date in the fall of 1992. A contract will be awarded in mid-1993. NOAA-O is scheduled for launch in 2001, NOAA-P in 2004, and NOAA-Q in 2007. The plan is for these satellites to provide afternoon coverage and Europe to supply morning satellites, beginning in 1997. NOAA will supply most of the operational instruments for both the AM and PM satellites.

3. LANDSAT Operational Program

A. Present Operational Status

LANDSAT 4 was launched on July 16, 1982. LANDSAT 5 was launched on March 1, 1984. The sensing instruments on both spacecraft are working nominally and each has redundant communications subsystems for data acquisition. LANDSAT 4 and 5 are used to acquire global data for U.S. users. LANDSAT 5 is also used for real-time direct broadcast of data to foreign ground stations.

B. Future

The President of the United States approved a new LANDSAT policy in February 1992, which reaffirms the importance of LANDSAT-type multi-spectral imaging and also provides a plan for maintaining continuity of LANDSAT coverage in the 21st century. A key element of the implementation of the policy is the assignment of management and funding responsibility for LANDSAT 7 to NASA and DOD. The Department of Commerce has the responsibility of completing and launching LANDSAT 6. The Department of Commerce will also have the responsibility of arranging for the continued operation of LANDSAT 4 and 5 until LANDSAT 6 becomes operational.

ARGENTINA

Servicio Meteorológico Nacional (SMN)

PART I Summary of the major highlights of research applications and operational changes

1.1 There was fairly good APT data reception from TIROS/NOAA satellites as well as METEOR APT and WEFAX from GOES 7 and METEOSAT 3.

1.2 Since May 1987, no data have been received from GOES due to the fact that the receiving system is unable to receive data from this satellite in the new format.

PART II Major research and development in the applications of satellite data,derived products and services

2.1 A study on surveying of crop and pasture areas using the Vegetation Index from NOAA images is presently being carried out.

2.2 A study on precipitation estimation derived from cloud convective system identification using satellite images has been delayed until GOES data can be received.

PART III A description of techniques development in the applications of satellite data,derived products and services

3.1 APT,WEFAX and HRPT images are currently being used in weather analysis and forecasting activities at the Buenos Aires Regional/Specialized Meteorological Center and at other local forecasting offices.

3.2 A nephanalysis covering the area from 20 S to 60 S and 30 W to 100 W is transmitted (twice a day) by the Buenos Aires Regional/Specialized Meteorological Center.

3.3 Since January 1990, a monthly report concerning the evolution of crops and pastures in Pampa Humeda zone of Argentina using the Vegetation Index from NOAA images has been issued by the National Meteorological Service.

3.4 At present, the Buenos Aires HRPT station receives NOAA AVHRR LAC and TOVS data from polar orbit NOAA 11 and NOAA 12 satellites as well as WEFAX from METEOSAT 3 images.

3.5 Archives of NOAA AVHRR satellite images have been established as follows:

- From July 1984 to October 1985, with the assistance of the RSMAS of the University of Miami, on digital tapes of 6250 bpi, covering the Argentina Atlantic area.
- Since October 1985, data have been stored on magnetic tapes without processing.

3.6 During 1991,a volcanic ash alert service was implement by Servicio Meteorologico Nacional (SMN) and Fuerza Aerea Argentina to detect and track volcanic ash to assist in general aviation avoidance. Using visible and infrared imagery from NOAA polar orbit satellites NOAA 11 and NOAA 12, the horizontal extent of volcanic ash was provided as frequently as every 6 hours.

PART IV System for satellite applications in current operational use

4. Same as described in 1986.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Plans include the attainment of temperature and humidity profiles from radiance inversion.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. None at the present time.

PART VII Other items (references,publications and names of scientists in charge, etc.)

7. Publications:

Brizuela A.B., Pujol G.C., Cababié R.J., "Evaluation of crop development using vegetation index and meteorological data", Proceedings of IV Latin American Meeting on Remote Sensing - Brasil 1986.

Paruelo J., Aguiar M., Pujol G.C., Galluscio R., León R., "Vegetation heterogeneity on arid and semiarid Patagonia: an analysis using AVHRR/NOAA satellite imagery", paper presented at the International Symposium toward a Quantitative Phytogeography, Rome, Italy.Accepted for publication in Annali di Botanico,Roma 1988.

Garcia M.J., "Monitoring of a Drifting Giant Iceberg in the South Atlantic ", paper published in the WMO Bulletin Vol 41 No 1, January 1992.

7.2 Correspondence should be addressed to:

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República Argentina

AUSTRALIA

Bureau of Meteorology

PART I Summary of the major highlights of research applications and operational changes

1.1 During 1991, the operational satellite reception and processing systems operated by the Australian Bureau of Meteorology performed extremely well. Data and products, primarily from GMS, NOAA, and GOES-WEST satellites were used. The Stretched-VISSR MDUS GMS reception station in Melbourne remains the main source of operational satellite imagery, and is backed up by SDUSs in Melbourne and Darwin. The Australian network of HRPT S-band reception stations now consists of four stations in Melbourne, Perth, Darwin, and Casey in Antarctica. Work has commenced on further development of a variety of applications of GMS and NOAA AVHRR data, and NOAA TOVS data is being processed with a statistical and a one-step physical retrieval scheme. The main tool for interactive processing and display of satellite data continues to be the Australian Region McIDAS (ARM).

1.2 The data collection systems on GMS and NOAA were extremely important for timely relay of data from remote observing platforms. The GMS DCP capability was used for about twenty AWSs, while reports from about 150 southern-hemisphere drifting buoys, including some AWSs, relayed via the Service Argos system on NOAA satellites, were received regularly over the GTS.

1.3 Operational use of the Personal Computer version of ARM (called PC-ARM), an interactive graphics processing and analysis system, was consolidated in forecasting centres. It provides meteorologists with an integrated data base including all satellite data, conventional observations, and NWP model data from the WMC Melbourne. The system is also used in research and training areas.

1.4 In terms of research and development, trial assimilation of physical TOVS retrievals continued into the Bureau's main Australian region NWP model, called RASP (Regional Assimilation and Prognosis Scheme). Total ozone estimates from TOVS data were being retrieved, and Cloud Drift Winds (CDWs), derived from GMS half-hourly images using ARM, continued to be produced. Other R & D work took place on sea ice monitoring, sea surface temperatures from AVHRR data, and volcanic ash monitoring.

1.5 Overall, 1991 has been a year of consolidation of the Australian Bureau of Meteorology's reception and processing network, as well as its dissemination and display capabilities for satellite data. Continuing work is focusing on more intensive operational use of applications of satellite data, development and planning for X-band stations, and R & D for utilisation of future types of satellite data.

PART II Major research and development in the applications of satellite data,derived products and services

2.1 The development of retrieval methodologies and the real time processing of TOVS data have continued. Both the physical and statistical algorithms used to process TOVS data from operational NOAA satellites (currently NOAA-11 and 12) in real time, have been expanded in several areas. Development work has centred on the production of temperature and moisture soundings, cloud height and amount, and in particular, the estimation of total ozone. A verification and optimisation program on the ozone retrieval algorithm is continuing using Dobson spectrophotometer and ozone sonde data. TOVS products are now being verified in real time. For example, the impact of these data on numerical weather prediction in the Australian region has been assessed by their use in a real time data assimilation experiment based on the RASP model. The National

Meteorological Centre (NMC) real-time assimilation cycle was used as a control run. The results indicate that the TOVS data can have a positive impact on forecast capability in the Australian region. For example, a detailed case study of the impact of locally produced TOVS retrievals on forecasts for an intense extratropical cyclogenesis situation demonstrated a significant improvement in forecasts with the TOVS data.

2.2 Research and development related to atmospheric sounding has also included work in support of the design of the AIRS instrument scheduled to fly on board a NASA Earth Observation System Polar Platform toward the turn of the century. The production of simulated data has proceeded with significant effort being expended to implement high resolution atmospheric transmittance calculations and to establish a system to generate synthetic data and to retrieve atmospheric information for these data.

2.3 The use of artificial intelligence and expert system-based methodologies to provide a forecast system for low cloud and rain using satellite and conventional data is being carried out in collaboration with the CSIRO (Commonwealth Scientific and Industrial Research Organisation).

2.4 A Cloud Drift Wind (CDW) package on ARM was run operationally four times a day (05, 11, 17 and 23 UTC) using GMS imagery. The CDW system algorithms and quality control methodology allow fully automatic generation of real time CDWs over most of the southern hemisphere portion of the GMS disk. Targets are automatically chosen form sequential GMS half-hourly images using image gradient and threshold criteria. They may be edited or supplemented by manually selected targets. CDWs are then calculated automatically by a target correlation technique where the initial search displacement is obtained from the Regional Assimilation and Prediction system, (RASP). Height assignment is done form the cold tail of the cloud temperature distribution, using temperature fields form RASP. Also, quality control of wind vectors is determined using RASP temperature fields.

2.5 The CDWs are being assimilated into the RASP model for evaluation of their impact. The verification involves comparison of CDWs with radiosonde data, and comparison of RASP forecasts which utilise CDW data with operational RASP products which do not use CDW data. The Australian Bureau of Meteorology's CDW work is contributing to a collaborative program with the Japan Meteorological Agency involving intercomparison of CDWs, which is currently proceeding.

2.6 Solar radiation estimates (radiative fluxes) from GMS data were being derived on an hourly basis, operationally.

PART III A description of techniques development in the applications of satellite data,derived products and services

3.1 Most work in this area was carried out using ARM, and includes basic improvements to the system's capability to process and manipulate satellite data. For example, mosaics of NOAA imagery and of sea surface temperatures (SSTs), remapped to a selected projection, are available in real time. Full capabilities involving looping, enhancements, overlaying, remapping, navigation and coastlines, etc were used operationally to improve the effectiveness of satellite data applications to forecasting and warning.

3.2 Development work with AVHRR data continued including further work on a set of algorithms for estimating Antarctic sea ice concentration, and development of low cloud detection algorithms. Considerable progress was made in the development of an operational algorithm for volcanic ash monitoring using AVHRR data; this software is being tested during 1992 with a view to using it operationally on the Bureau's Darwin HRPT station, as a complementary detection method to use of GMS images.

3.3 A collaborative program involving substantial input from the Royal Australian Navy has resulted in the development of an advanced software package which allows automatic generation of SSTs from AVHRR data. Australian region mosaics of SSTs for the Australian region are being produced in real time. Further ground truthing and refinement of the algorithms for the Australian region is proceeding through 1992. Software to derive NDVIs over the Australian region using NOAA AVHRR was commenced with a view to providing regular products for use in fire weather forecasting and in climate monitoring.

3.4 Further development of algorithms to estimate rainfall rates from GMS data has continued. Three techniques have been adapted to the Australian region and are being evaluated; they are the Arkin threshold method; simplified Griffith-Woodley technique; and convective stratiform technique.

3.5 Algorithm development to provide cloud and surface characteristics from AVHRR and GMS data has continued. Algorithms to indicate the presence of cloud and surface types (e.g. ice and water) have been developed. These techniques have been refined using the integrated data base in ARM in combination with AVHRR data to classify cloud types. Methodologies including maximum likelihood techniques and neural networks have been used in these studies. These algorithms should provide useful guidance for both the regional and forecast environment and also for the Australian Casey station in Antarctica. They are also being used to provided a regional cloud climatology.

3.6 A program to improve the navigation of real time satellite images using automatic landmark recognition neared completion, and has resulted in a most pronounced improvement in the accuracy of navigation for GMS images processed in real time in the Bureau of Meteorology. Navigation is now accurate to one pixel. The new system is being implemented operationally in 1992. This particular project is the result of very successful collaboration between the Bureau and the State Meteorological Administration of China.

PART IV System for satellite applications in current operational use

(a) Imagery

4.1 The MDUS in Melbourne receives full disk visible and infrared imagery from GMS on an hourly basis, and half-hourly four times per day. The data are ingested directly into the Bureau's Fujitsu M382 mainframe computer system, on which all processing is done using ARM software. Calibrated and navigated imagery is disseminated in real time to service outlets throughout Australia (the World Meteorological Centre, the National Meteorological Centre, 7 Regional Offices, two Meteorological Offices and 29 Weather Services Offices). There are SDUSs in Melbourne and Darwin as backup to the Melbourne MDUS. The principal applications of GMS data lie in the use of a variety of imagery enhancements including use of the Dvorak technique, solar radiation estimates and CDWs. HRPT S-band stations in Melbourne, Perth, Darwin and Casey in Antarctica are used to receive NOAA AVHRR, TOVS and DCP data. Melbourne data is ingested into the Fujitsu M382 and processed using ARM. Data from the other stations is ingested and processed locally on IBM PCs. Applications include specially mosaicked and enhanced imagery, and developmental versions of sea ice monitoring software and normalised difference vegetation index software. In addition to imagery applications, operational DCP processing is performed in Melbourne to derive real time DCP data relayed via the NOAA satellites.

4.2 APT receivers are available in four Regional Offices and are used at Antarctic bases at Mawson, Davis and Casey and on Antarctic vessels, to supply forecasters with NOAA or METEOR imagery. WEFAX transmissions from GOES-WEST are received via a reception station in Brisbane and these provide NOAA southern hemisphere imagery for WMC Melbourne operations.

4.3 All the above forms of satellite data are used operationally, and most are used in research and development, and in training and educational activities undertaken by the Bureau.

(b) TOVS

4.4 TOVS data (in TIP form) are acquired directly by reception of HRPT broadcasts, and are processed operationally using a statistical retrieval scheme and on an evaluation basis using a physical retrieval scheme, as described earlier. With the statistical scheme, the data are processed to about 70 km resolution within about 15 minutes of orbit time. The routine display consists of analysed fields of 1000-500 hPa thickness, 250 hPa geopotential height, and superimposed geostrophic wind vectors. Displays in other forms are available on PC-ARM terminals, including physical TOVS retrievals. The physical retrieval scheme provides some significant improvements over the statistical scheme, including better moisture determinations.

4.5 TOVS data from WMC Washington, processed by NOAA/NESDIS is received via the GTS, and is used operationally.

(c) Operational satellite display systems

4.6 The main platform for operational display and analysis of satellite data and applications is PC-ARM. It provides meteorologists with an integrated data base (as described above) and a comprehensive suite of applications programs to allow such things as satellite orbit display, enhancements, contrast stretching, looping, overlays, etc. PC-ARM is used in WMC Melbourne, seven Regional Forecasting Centres, severe weather forecasting areas, the Bureau's Training Centre, and many other development areas. Satellite applications such as NDVIs, CDWs, sea ice, rainfall estimates and so on are displayed and developed using PC-ARM and the Bureau's ARM mainframe system. Full resolution GMS S-VISSR and NOAA AVHRR imagery, plus TOVS and DCP data are available in real time on PC-ARM, together with complementary data.

4.7 Two other less sophisticated but highly effective systems complement PC-ARM in terms of satellite data display, and are called Digital Satellite Broadcast (DSB) and Digital Facsimile (DIFACS). DSB is used in Regional Forecasting Centres to display GMS imagery with a 256-level greyscale and selectable colour enhancements and looping. DIFACS is used in operational offices and is the replacement for the Bureau's aging analogue fax network. It provides display and hard copy of NWP charts, and GMS imagery at reduced resolution.

(d) SATOB data

4.8 CDWs from GMS, GOES and METEOSAT, received via the GTS, are routinely used in WMC Melbourne analyses. The GMS winds are particularly useful in analyses over otherwise data sparse ocean areas around Australia, and as input for the automated tropical analysis scheme run by Darwin RMC.

(e) DCP data

4.9 Drifting buoy data are received over the GTS from the Service Argos DCP system on NOAA satellites, and provide, inter alia, vital surface pressure information for WMO hemispheric and Australian region analyses. DCP data are also stripped out of the TIP data received in real time from stations in the Australian national HRPT reception network, and are used in forecasting areas including WMC Melbourne.

(f) Hydrological data

4.10 Operational Flood Warning Centres have now been established in all States and the Northern Territory of Australia. These centres provide flood warning services to response groups within their respective regions. Preliminary progress has been achieved in the use of satellites for the detection of flood movement in large inland river systems, for collection of field data (via Inmarsat-C) and in the estimation of precipitation.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 During the Antarctic summer of 1990/91, the HRPT S-band reception station at Casey was installed and commissioned, and is now operational. The station is a joint initiative of the Bureau of Meteorology and the Antarctic Division of the Department of the Arts, Sport, the Environment and Territories of the Australian Government. During late 1991 another HRPT station was commissioned in Darwin, thus completing the Bureau's network of four stations. DCP installations are continuing at remote locations, and drifting buoys are being deployed, for data relay via satellite.

5.2 During 1992 and subsequent years one of the Bureau's major plans is to continue to consolidate and to further operationally implement a number of NOAA AVHRR and GMS applications, including SSTs, sea ice monitoring, volcanic ash detection, flood monitoring, low cloud/fog detection, NDVIs and operational CDWs from GMS imagery. In addition further enhancements to the Bureau's physical TOVS retrieval system are in progress.

5.3 As part of a Working Arrangement with China's State Meteorological Administration, the Australian Bureau of Meteorology is designing and constructing a Turn Around Ranging Station in Melbourne to support China's planned geostationary meteorological satellite FY-2. A data reception and processing station will be developed later.

5.4 The Australian Bureau of Meteorology is a member of a consortium which is building an X-band reception and processing station in Hobart for ESA's oceanographic satellite, ERS-1.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6.1 Calibration data from NOAA/NESDIS and from JMA are used respectively for NOAA and GMS imagery. Ground truth and NWP output are used to monitor and verify a variety of satellite products including TOVS soundings, surface temperatures, rainfall estimates, CDWs NDVIs and SSTs. Nearly all data are archived.

PART VII Other items (references,publications and names of scientists in charge, etc.)

7.1 Lead scientists and staff for enquiries are as follows:

- satellite systems, reception, processing, display systems, applications, and operational products (Mr Bruce Neal);
- research and development in remote sensing (Dr John Le Marshall);
- training aspects in satellite meteorology (Mr John Mottram);
- operational use of satellite products in WMC Melbourne and National Meteorological centre (Dr Geoff Love).

For policy issues and for information on research projects and lead scientists at related Australian institutions, the contact is Dr Doug Gauntlett, Deputy Director (Research and Systems).

All the above scientists may be contacted at the Australian
Bureau of Meteorology, GPO Box 1289K, Melbourne, Victoria,
Australia 3001.

Some of the Bureau's more recent satellite and related publications are as follows:

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CANADA

Environment Canada, Atmospheric Environment Service (Meteorology)

PART I Summary of the major highlights of research applications and operational changes

1.1 Research and development on applications of satellite data continued in three main areas: use of satellite data in regional weather centres, assimilation of satellite data into numerical weather prediction models, and use of satellite data in climate research and monitoring and in hydrometeorological applications. Use of satellite image analysis facilities was expanded in regional weather centres, and a number of new satellite data applications became operational at the Canadian Meteorological Centre (CMC). The major changes in operational systems currently planned are the implementation of a distributed system for reception of GOES-NEXT data and the relocation of the Toronto HRPT station to Halifax, Nova Scotia.

PART II Major research and development in the applications of satellite data, derived products and services

Explosive Cyclogenesis in the Eastern Pacific

2.1 The Atmospheric Environment Service (AES) Pacific Region continues to develop their PROBE technique for the prediction of explosive cyclogenesis in the Eastern Pacific. The next step is to further enhance the use of artificial intelligence techniques for evaluating the development-potential factors. (N. McLennan and L. Neil, Pacific Weather Centre).

Assimilation of Satellite Data into Numerical Weather Prediction Models

2.2 An algorithm to derive humidity profiles using VIS, IR and water vapour image data from geostationary satellites was completed (Garand, 1992). The algorithm was tested in a two-week data assimilation experiment using summer-1991 data. A decision on operational implementation of the algorithm will be based on an additional experiment using winter data. Development of rainfall estimation techniques for NWP assimilation continued through participation in the Global Precipitation Climatology Project Algorithm Intercomparison Program.

2.3 Work is continuing on improving our assimilation of SATEMS and on experimental assimilation of raw TOVS radiances following Eyre's one-dimensional variational approach (Chouinard and Greaves, 1991; Chouinard et.al., 1991). Several projects aimed at improving our ability to do the TOVS forward problem are being undertaken in support of this work. Systematic errors in TOVS forward-model calculations in overcast cloud conditions were investigated by Turner and Steenbergen (1991a,b). This study used the CATHIA data base compiled by Rochard and co-workers in Lannion, France. The results indicate that TOVS forward-model biases in clear sky conditions are not generally applicable to overcast conditions. Biases in overcast conditions were reduced by specifying cloud emissivity as a function of wavelength and by including simple terms describing reflection of solar radiation and downwelling atmospheric radiation from clouds. A simulation of the effect of increasing carbon dioxide mixing ratio on HIRS temperature sounding channels using the GENLN2 line-by-line model was begun. Publication of the results is expected in 1992.

2.4 Preliminary experiments were carried out with a modified MSL pressure and wind analysis incorporating Ekman balance in the boundary layer (Polavarapu and Steenbergen, 1991). This project is aimed at making more effective use of scatterometer winds.

2.5 Use of satellite information in support of modelling and parameterization studies is increasing. Cloud, precipitation and humidity information from satellite imagery was used in a numerical model case study of the Montreal flash flood of 14 July 1987 (Mailhot et al, 1992; Belair et.al., 1992); SSM/I information was used in evaluation of a predictive cloud water scheme in the Canadian regional finite-element model (Pudykiewicz et al. 1992).

2.6 An ice-cover analysis was developed which makes use of Special Sensor Microwave Imager (SSM/I) data over North America. For the rest of the globe, climatology is used. The analysis has a resolution of 100 km, is run once a day and uses a simple averaging of the SSM/I data received within a 24-hour period. It was implemented operationally at CMC in the spring of 1992 and is used as input into CMC's global and regional models. (J. Hallé, CMC)

Use of satellite data for ocean wave modelling

2.7 Work is planned to use scatterometer winds from the European Space Agency's ERS-1 satellite in a spectral ocean wave model as part of the cal/val process for wave spectra from the SAR (AMI) instrument on the same satellite. The scatterometer winds will be combined with conventional wind data (e.g. ship, buoy) to produce a comprehensive wind-field analysis for the two-week period of the calibration/validation field experiment conducted off the coast of Newfoundland in November, 1991 (Dobson et al., 1992). The analysis will be used to drive the operational ocean wave model in a hindcast mode to generate wave spectra, which will then be compared with the ERS-1 SAR spectra. The results of this study will provide a useful input for SAR data assimilation into operational ocean wave models. (M. Khandekar, Forecast Research Division).

Evaluation of ERS-1 scatterometer winds for short-range marine forecasting

2.8 The Meteorological Services Research Branch (MSRB) is coordinating an evaluation of ERS-1 scatterometer winds by regional weather offices in Vancouver, Edmonton, Halifax and Gander. Regional forecasters will assess the impact of the scatterometer winds on their analyses. Objective comparisons analyses with and without scatterometer winds will also be made. The evaluation was originally planned for autumn-winter 1991-92, but had to be postponed to 1992-3 due to delays in establishing a datalink from Europe to Canada. (P. King, Meteorological Services Research Branch).

BOREAS - Boreal Ecosystems Atmosphere Study

2.9 BOREAS is a co-operative Canada/US(NASA) field and analysis study aimed at improving our understanding of the interactions between the boreal forest biome and the atmosphere in order to clarify their roles in global change. Specific objectives are to improve understanding of the processes which govern the exchanges of energy, water, heat, carbon and trace gases between boreal ecosystems and the atmosphere, and to develop and validate remote sensing algorithms for transferring this understanding from local to regional scales. Two 20 x 20 km study areas (near the northern and southern limits of the Canadian boreal forest) have been chosen. The science team is to be finalized in mid-1992. Installation of flux towers and climate stations and definition of meteorological and hydrological support has been initiated. Intensive study periods are scheduled for 1993 and 1994. (B.E. Goodison, Canadian Climate Centre).

Snowcover Monitoring using SSM/I Data

2.10 Algorithms have been developed and tested for the determination of snow water-equivalent, snow extent and snow state (wet/dry) using 19 and 37GHz SSM/I data, with special emphasis over the open prairie region of Canada. These algorithms were included in an international intercomparison conducted by the US National Snow and Ice Data Centre. A wet-snow indicator has been developed and tested, allowing the mapping of snow extent during wet snow conditions. Current research focuses on the validation of the snow products in other open areas, such as the Arctic, and on the development of algorithms for forested regions.

Weekly real-time snow water-equivalent maps are distributed by facsimile to co-operating meteorological and water resource agencies. This project is a major component of the CRYSYS ("Use of a Cryospheric System to Monitor Global Change in Canada") project within NASA's Earth Observation System (EOS) Program. (A.E. Walker and B.E. Goodison, Canadian Climate Centre).

Monitoring of Lake Ice Freeze-up and Break-up

2.11 Changes in the dates of lake freeze-up and break-up are a potential indicator of climate variability and change. A study was initiated during the 1991/92 winter to assess the utility of using SSM/I passive microwave data (85GHz), NOAA AVHRR data and conventional ground-based observations to identify the time of freeze-up and break-up of lake ice. Each data set is seen to complement the others. Algorithms are to be developed. Initial assessment will be based on large lakes in the Northwest Territories. (A.E. Walker, N. Bussieres, W. Skinner, Canadian Climate Centre).

PART III A description of techniques development and applications of satellite data, derived products and services

Satellite Image Analysis Systems

3.1 Work is underway at the Pacific Weather Centre on a new-generation workstation called METWORKSII, which is intended for use by the operational forecasters in all AES forecast centres. The system will be able to display, in a timely fashion, all meteorological data sets available from different acquisition systems, including the overlaying of meteorological contours and observations on satellite imagery. (J. Spagnol, Pacific Weather Centre).

3.2 The AES Western Region image analysis system has been modified to use the MOTIF interface. While there are some changes, functionality remains essentially the same. In the Central Region, display software has been developed which integrates satellite, radar and lightning data. New display hardware and software has allowed operational meteorologists to use medium and high resolution GOES and NOAA images to detect and track severe convective storms. Work by Anderson (1986) and Dudley (1992) has identified several signatures of threatening thunderstorms which can be used in an operational setting. Meteorologists are also using GOES infrared imagery to monitor winter storms and forecast heavy snowfalls. Use of the infrared data has lead to an improved capability to monitor storms, especially in remote areas, and to refine predictions of snowfall amount.

Atlas of Southern Canadian Prairies Winter Snowcover Variability from Satellite Passive Microwave Data

3.3 An atlas depicting Canadian Prairies snow cover is being derived from Nimbus-7 SMMR passive microwave satellite data for the winter seasons of 1978/79 to 1985/86. This work is being co-sponsored by the Canadian Space Agency as a contribution to the International Space Year (1992). A time series of snowcover conditions (snow water-equivalent) is being prepared and the seasonal and interannual variability in snowcover will be assessed. The atlas will demonstrate the capability of monitoring climate/hydrology variability using snowcover information from satellite observations with Canadian-developed algorithms. (A.E. Walker, Canadian Climate Centre).

Integration of Conventional and Remotely Sensed Observations of Climate Parameters

3.4 CLIGRID is a project to develop and evaluate techniques for objectively integrating conventional and remotely-sensed observations of climate parameters. A workstation version of the software is currently under design using CASE tools. A low-cost microcomputer version, called MICRO-CLIGRID has been developed in-house. It is a production system that maps GOES data, interpolates ground station data, transforms and displays arrays and exports them to various GISs. It was used in 1991 to generate evapotranspiration estimates for the Saskatchewan Prairie Regional Evaporation Study and to implement a version of the RAINSAT algorithm. There are about 15 MICRO-CLIGRID users in Canada at present. (W.D. Hogg, Canadian Climate Centre).

Arctic climate Monitoring Using Remote Sensing

3.5 A Canadian Sea Ice Atlas using SSM/I microwave data from 1987 to 1990 is being produced in conjunction with the Canadian Space Agency as part of International Space Year efforts. The theme of this atlas centres on remote-sensing applications to monitor sea ice and the seasonal changes in Arctic climate. (T. Agnew, Canadian Climate Centre).

3.6 Passive microwave data from SSMI and historic data from SMMR continue to be used to monitor climate/sea-ice trends in Canadian waters. The information is used in Climate Perspectives, a publication produced by the Canadian Climate Centre which summarizes climate events over the previous week and month. (T. Agnew, Canadian Climate Centre).

Frost Warning Diagnosis and Verification

3.7 An application was developed in the Agro-Met Division of the Québec Weather Centre in 1990 to diagnose frost and verify frost warnings issued in spring and fall by the Québec Forecast Centre. A special enhancement curve is applied to IR GOES satellite images received from Toronto. The images are displayed, zoomed and animated on the forecaster's workstation using Image Manager software. By comparing the radiance values at sunrise with the surface and ground temperature from AES observation and climatological stations, thresholds can be established to correlate radiance values and frost on ground. Under ideal radiative situations, satellite imagery helps identify the areas where ground frost is most probable. A verification was performed and an internal report produced. (R. Léonard, Québec Weather Centre).

"RAINSAT 2"

3.8 RAINSAT 2 is an operational system for processing and displaying integrated geostationary meteorological satellite data and weather radar data. It became operational at the Québec Weather Centre in 1991. It allows forecasters to visualize products based on both satellite and radar data. The basic RAINSAT 2 product is derived from a comparison over the same domain of the normalised and sun-corrected Visual GOES data and equivalent IR imagery, with the radar echos of the McGill Weather Radar Observatory (Montreal) and the King City Radar (Ontario). Contingency tables of RAIN and NO-RAIN are generated and a probability-of-precipitation matrix can be derived. Other derived products include qualitative maps of Rain, No-Rain, Cloudy and Thunderstorm conditions. Rainfall rate maps, probability-of-precipitation maps and 1-to-6-hour forecast probability of precipitation and rainfall rate maps are generated for the whole satellite sectorized domain. An interactive application called DIALOGUE allows forecasters to modify the product's presentation and calibration and allows modifications in enhancement curves for optimal use. (H.P. Biron, Québec Weather Centre).

PART IV Systems for satellite applications in current operational use

4.1 AES currently operates three GOES direct readout stations (Vancouver, Toronto, and Montreal/CMC) and two HRPT stations (Toronto and Edmonton). These stations distribute products to forecast and briefing offices via a broadcast communications system ("METSIS"). The Edmonton HRPT station and the GOES facilities in Vancouver and Montreal produce and transmit a number of products in polar stereographic projection. AES also operates several APT stations in the Yukon and Northwest Territories. An APT station has also been added in Vancouver for receiving NOAA and Meteor data as part of the AES NO-GOES contingency plan. Future planned changes to the AES system are outlined in PART V below.

4.2 The antenna and receiving electronics at the Edmonton HRPT station were replaced in April 1992. Also, the archive medium for this station was changed from 9-track CCT to 8mm Exabyte tape. One tape contains one day of satellite passes. The data reside in Edmonton for about 1-3 months before being sent to Toronto. The significant change is that in the past, "raw" data were overwritten approximately every 10 days; now all raw data are retained. The new system became operational in mid-April, 1992.

4.3 Data Collection Platform (DCP) data from buoys in the Arctic and Pacific Oceans are received and processed in Edmonton. These are formatted in DRIBU code and placed on GTS circuits. DCP data are also received and processed in Toronto.

4.4 CMC is in the process of installing a Meteosat receiving station (PDUS) in Montreal. This station will receive Meteosat data directly from METEOSAT-3, now located at 50 degrees West, and will also be capable of receiving Meteosat data relayed via GOES-6.

4.5 An algorithm for sea surface temperature retrieval from GOES data, originally developed at the University of Wisconsin, is being run operationally at CMC. Both the GOES SST retrievals and NOAA 11 and METEOSAT retrievals received over the GTS are used in the CMC operational SST analysis.

4.6 CMC receives SSM/I brightness temperature files from the U.S. Navy in Monterey in near-real time. Charts of precipitation rate and surface wind speed over the oceans, derived from the SSM/I temperatures, are transmitted to forecast offices on a regular basis. Derived ice data are provided to the Canadian Ice Centre and the Arctic Climatology Group in Toronto (Downsview). The algorithms used to process the SSM/I data were developed at the Institute for Space and Terrestrial Science at York University in Toronto. During 1992, CMC will begin receiving global coverage of SSM/I data via a U.S. Joint Ice Centre/Canadian Ice Centre communications link. This will allow CMC to run operationally a truly global ice-cover analysis. (J. Hallé, CMC).

4.7 Since 1980, the Climate Adaptation Branch of the Canadian Climate Centre has carried out operational surface-water-temperature monitoring of the Great Lakes and Bay of Fundy from NOAA polar-orbiting satellite Channel 4 AVHRR (9.5 to 11.5 micrometre) data. Surface-water-temperature maps are distributed to AES regional weather offices and to other organizations concerned with water resource management. The work continues. (W. Hogg, Canadian Climate Centre).

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 AES is preparing to receive, process and distribute data from the next generation of GOES satellites. Under its GOES-90 project, ground systems are now being developed and are scheduled for implementation beginning in 1992. The current system is based on centralized reception and processing of GOES data, followed by distribution of products to regional users via a broadcast telecommunications system (METSIS). The new system will meet the requirements of the weather service component of AES with a more distributed network for receiving and processing GOES-Next data. Ground stations will be installed on-site for the large-data-volume users in most forecast offices. These stations will connect to local area networks where forecaster workstations will have access to the GOES data sets for interactive processing and display, or for integration with other data sets. A broadcast telecommunications system will also be used to provide data in digital format to remote users in weather presentation offices. Installation of the downlink equipment at weather centres will commence during 1992. Until the first GOES-Next satellite is launched, this equipment will provide access to the current GOES-7 signal or to METEOSAT PDUS transmissions. (B. Green, GOES-90 Project Manager).

5.2 The AES Toronto HRPT ground station is now obsolete. For a number of logistical reasons, it will be replaced with a new station in Halifax, Nova Scotia. The plan is to purchase a commercial HRPT system employing "off-the-shelf" hardware and software. The new station is scheduled for installation in the spring of 1993. It will serve AES forecast and briefing offices in eastern Canada and the Canadian Ice Centre in Ottawa. (K. MacDonald, Maritimes Weather Centre).

5.3 Processing software and hardware at the Edmonton HRPT station is expected to be replaced by March, 1993. The new system will allow much greater flexibility in the type of data processing that can be performed (such as remapping imagery to standard map projections, image arithmetic, etc.) with greater speed and lower costs than the current system. (R. Goodson, Alberta Weather Centre).

5.4 It is planned to replace the GOES-Tap service at the Pacific Weather Centre in Vancouver with a WEFAX station by early 1993 to make GMS imagery more readily available. GMS coverage is required to monitor the progress of dissipating tropical storms as they enter the westerly flow, following which their influence may be felt on North American coasts. The WEFAX station is another component of the NO-GEOS contingency system. (J. Spagnol, Pacific Weather Centre).

PART VII Other items (references, publications and the names of scientists in charge, etc.)

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CANADA

Environment Canada, Conservation and Protection
(Operational Hydrology)

PART II Major research and development in the applications of satellite data, derived products and services

2.1 As remote sensing technology evolves to become more useful in quantifying hydrologic variables, more effort is being put into re-designing hydrologic simulation models to make direct use of such data. Environment Canada is currently evaluating two distributed (square-grid) hydrologic modelling systems for flood forecasting and other applications. The HYDROTEL system was developed under contract to the Government of Canada by the Institut National pour La Recherche Scientifique - Eau, of the University of Quebec. The WATFLOOD system was developed in the 1980s by the University of Waterloo. Each model was designed for use on low-cost micro-computers and to interface with image analysis and geographic information systems. (G. Kite, National Hydrology Research Institute, Saskatoon).

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 A regional-scale land-use update has been completed for the provinces of Prince Edward Island, Nova Scotia and New Brunswick. The Strategic Land Use Database (SLUD) was developed using Landsat and SPOT colour composite satellite imagery for the years 1986 to 1988. The images were projected onto 1:50,000-scale topographic maps using a PROCOM-2 optical transfer device where they were classified into 21 land-use classes. These classes include features such as urban development, croplands, pasture, mines and quarries, wetlands and forests. These base maps were aggregated up to the 1:250,000 level and were subsequently scanned into the Canadian Geographic Information System (CGIS) in Ottawa. Provincial databases were downloaded from CGIS and imported into SPANS, a micro-computer-based GIS developed by TYDAC Technologies. (D. Wilson, Water Resources Directorate, Atlantic Region).

3.2 The Strategic Land Use Database (SLUD) is being used for a number of environment modelling studies. A regional risk assessment for toxic chemical contamination based on land use and population has been completed and published. An additional risk assessment for acid drainage in Nova Scotia is presently underway. Other applications include development of a stress-response model for agricultural activity using nutrient concentrations in Prince Edward Island streams. The addition of a DTM for the three maritime provinces will greatly enhance the capability to provide regional soil erosion risk assessments. (G. Howell, Water Resources Directorate, Atlantic Region).

PART IV Systems for satellite applications in current operational use

4.1 Out of some three thousand hydrometric active gauging stations operated by the Water Survey of Canada (WSC), about 900 are equipped with Data Collection Platforms (DCPs) which transmit environmental data via GOES satellites. The DCP stations are usually located in remote northern areas accessible only by helicopters or aircraft equipped with floats or skis. The environmental data collected include: water level, velocity of water, discharge, water temperature, air temperature, temperature inside shelter, ice thickness, presence or absence of ice, wind speed and direction, precipitation, air pressure, and various parameters indicating the performance of instruments.

4.2 Until the end of March, 1992, the Atmospheric Environment Service (AES) and Conservation and Protection shared the operation of three Direct Readout Ground Stations (DRGSs) that received data directly from GOES East and West satellites. In April, 1992, the DRGSs were decommissioned and both agencies moved to the AES Meteorological Information Service (AMIS) for distribution of DCP data using Telesat Canada's ANIK satellite. (K. Wiebe, Monitoring and Surveys Division).

CHILE

Direccion Meteologica de Chile

PART I Summary of major highlights of research applications and operational changes

1.1 No significant changes occurred in this field.

PART II Major research and development and applications of satellite data, derived products and services

2.1 No activities were carried out in this field.

PART III Description of technique development and applications of satellite data, derived products and services

3.1 Satellite images are used in preparing synoptic charts, monitoring cloud systems and calculating the temperature of cloud tops and sea and land surfaces.

PART IV System for satellite applications in operational use in 1991

4.1 The service has a VISSR station, which receives GOES imagery and WEFAX information, as well as five low-resolution receivers in the forecasting centres throughout the country, which receive GOES, NOAA, METEOR and METEOSAT imagery used in operational meteorology.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Five automatic platforms are currently being installed which will transmit meteorological information via satellite from various parts of the country to the forecasting centres.

PART VI Validation and verification of satellite data and derived products used in operations

6.1 This type of activity will be carried out in the future.

PART VII Other items (references, publications and names of scientists in charge, etc.)

7.1 No publications exist.

CHINA

Satellite Meteorological Centre
State Meteorological Agency

Part I Space Segment

1.1 FY-1B satellite, the second polar orbiting meteorological satellite of PRC, was launched successfully on September 3, 1990 from the Taiyuan Satellite Launch Center by a Long-March-4 rocket.

1.2 The satellite completed its orbit adjusting and testing period on September 23, 1990 and then went into the normal operation.

1.3 FY-1B satellite suffered a failure on February 14, 1991 as the nitrogen in the reaction propulsion system was exhausted. The satellite tumbled, basically around the pitch axis. In order to save the satellite, the Ground Operation Control Center initiated the earth magnetic damping system of the satellite to adjust the attitude.

1.4 After adjustment, the satellite re-acquired the earth successfully on May 2, 1991. It then worked intermittently up to August 5.

Part II Ground segment

2.1 The ground segment for the FY-2 geostationary meteorological satellite is under construction.

2.2 Command and Data Acquisition Station (CDAS)

The CDAS's 20 meters antenna has been installed and tested and additional equipment is now under installation.

2.3 Data Processing Center (DPC)

The DPC consists of a front-end communication sub-system, a host computer, an image/graphic workstation, and a local product collection and distribution network.

2.3.1 Front-end communication subsystem

The main tasks of the front-end communication sub-system are:

- To ingest the S-VISSR data of the FY-2 satellite in real time.
- To exchange data, output the S/DB parameters and DPC operation status from the host computer to the CDAS, input the DCPR, ranging data, telemetry data and operational schedule from CDAS to host computer.

2.3.2 Host computer

The host computer consists of 2 sets of M770/10 (Fujitsu) computers. The speed of the computers is 10 MIPS (for each set), the memory is 64MB. The main tasks of the computers are:

- To generate disk file and input telemetry data, ranging data, DCPR data and conventional data.
- To process telemetry data.
- To process DCPR data.
- To predict and calculate the satellite orbit and attitude.
- To create S/DB parameters.
- To generate various meteorological products.

2.3.3 Image/graphic workstations (2 sets SUN 4/490)

The main tasks of the image/graphic workstations are:

- To process image and synoptic products.
- To do landmark navigation.
- To generate wind vectors.

2.3.4 Local product collection and distribution network

The tasks of the network are:

- To ingest the synoptic chart from National Meteorological Center of SMA.
- To distribute image products.
- To transmit the LR-FAX and WEFAX image and graphic products to CDAS (including the processed cloud image).

The computer system for the DPS was installed at the end of 1991. The system is under adjustment and the software is under development.

2.4 Satellite Operation and Control Center (SOCC)

The host computer of SOCC is the HP 9000 Model 1240 Fault Tolerant Computer. It has 4 image/graphic workstations. The computer for SOCC was installed in August 1991. The software for SOCC is under development.

Part III Meteorological Satellite Data Application

SMA has put more attention to the flooding and drought monitoring recently, as they often create heavy damages to the country.

3.1 Flooding monitoring

In the summer of 1991, the Anhui and Jiangsu provinces of Southeast China suffered serious flooding. During the flood period, SMC/SMA used the satellite data from both FY-1B and NOAA satellites to monitor continuously the change of the flooding. The flooded area derived from meteorological satellite images was correlated to the TM images. With the data from the visible channels (0.48--0.53um and 0.53--0.58um) of the FY-1B satellite, the depth and turbidity of the flood were also measured.

3.2 Drought monitoring

With a large territory and various climatic regions, droughts occur in different parts of China every year. For drought relief, the droughted situation is needed. Satellite remote sensing is one way to get the drought information among all the techniques. During the which drought occurred in the central China in the autumn and winter of 1991, SMC/SMA used the satellite observed difference between the daily maximum and minimum (diurnal range) to derive the thermal inertia value, then established an estimating model with the combination of the values and the in-situ measurements of the soil water content at the depth of 10, 20 and 30cm. This model played an important role in estimating the drought situation during the drought of Central China.

3.3 Vegetation index monitoring

The 10 days and monthly national vegetation index mosaic (NDVI composite image), which are derived from AVHRR data of NOAA satellites, are used to monitor the vegetation growth condition over an extensive region in the recent year. The result shows that the vegetation growth condition is closely related to the short-range climate change.

Part IV Development and Research

4.1 The development of the PC based TOVS data processing and graphic/image display system has been completed. It gave a deep impression to the participants of the WMO regional training seminar on the use of environmental satellites data in meteorological applications for RA II and RA V, which was held by WMO and SMA at Beijing in October 1991.

4.2 The retrieval results from the TOVS water vapour data were used to analyze the cause of the formation of the storm rainfall which occurred in Southeast China in the summer of 1991. The results showed that the weather systems' water vapour transportation were present in the satellite data.

4.3 Through the comparison of the results from several retrieval methods, it shows that the improved one-step physical retrieval method has a fairly good result for the middle and lower convective layers, as well as the surface.

4.4 In addition, good results have been obtained using the TBB data of geostationary satellite to analyze and study the severe mesoscale convective system, typhoon and storm rainfall etc. A fax chart software for the GMS Lambert projection was developed and the simulation and analysis for FY-2 satellite's water vapour channel selection were also executed.

COLOMBIA

Instituto Colombiano de Hidrologia, Meteorologia Y
Adecuacion de Tierras - HIMAT -

PART I Summary of major highlights of research applications and operational changes

1.1 There were no significant changes in the operation of the APTS-3C satellite equipment and weather display system C3000G.

1.2 During 1992, Data Collection Platforms (DCP) were installed for a total of 42, to transmit hydrometeorological information, via GOES satellite, to earth located in Bogota and Cali.

PART II Major research and development and applications of satellite data, derived products and services

2. Software applications for hydrometeorological data from DCPs were developed in order to store, analyze and produce outputs useful to several types of users.

PART III Description of technique development and applications of satellite data, derived products and services

3. WEFAX data are used operationally for monitoring and tracking the development of weather systems and storms, in the provision of warnings of severe meteorological conditions to aviation, shipping and the general public, and also in weather chart analysis.

PART IV System for satellite applications in operational use in 1991

4.1 Image reception

ALDEN APTS - 3C receiving station
ALDEN color display system C3000G

DCP information

SUTRON receive stations in Bogota and Cali
42 DCPs located in the main river basins

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Plans are being made to upgrade the present receiving system in order to obtain high resolution imagery.

5.2 In the same way, additional DCPs will be installed to provide information for specific activities such as frost forecasting, reservoir regulation, hurricances, etc.

PART VI Validation and verification of satellite data and derived products used in operations

6. Not applicable

PART VII Other items (references, publications and names of scientists in charge, etc.)

7. The personnel in charge of the satellite systems involved in the different projects are:

Jorge Ivan Valencia Franco
Jorge Zea Mazo
Oscar Arango Botero

Address:

HIMAT
Carrera 5 No. 15-80 Piso 18
Santafe de Bogota
Colombia
South America

CZECHOSLOVAKIA

PART I Summary of the major highlights of research applications and operational changes

1. Severe convective storms research, using AVHRR imagery, Meteosat SDUS installation, Experimental TV broadcasts.

PART II Major research and development in the applications of satellite data, derived products and service

and

PART III A description of techniques development and application of satellite data, derived products and services

2.1 A research (based on AVHRR/HRPT data) of convective storms over Europe and the Mediterranean continues as a part of long term project goal of which is deeper theoretical background for nowcasting purposes in the future. Knowledge of structure, behaviour and climatological aspects of large or severe convective systems in this area still remains far from satisfactory, partly due to lower level of radar technique in the region. Satellite observations are capable to overwhelm partly this certain lack of sophisticated radar observations, however data from NOAA as well as from meteostat have to be utilized simultaneously. This is being proved in starting co-operation between CHMI in Prague and FISBAT -C.N.R. in Bologna, Italy.

2.2 As to applications, the most important progress has been installation of PC-based SDUS (UKW-Technic Electronic GmbH, Germany), that enabled regular (every 2 hours, from 7.55 a.m. till 19.55 p.m.), T.V. broadcasts on actual weather and very short range forecasts, together with information about air-pollution in most polluted areas in the Czech region. Meteosat WEFAX data are used as animation sequences (Europe - last 12 hours, Central Europe - last 6 hours, with the last image not older than 1 hour when broadcasted). The whole broadcast is being prepared in CHMI, the team consists of two persons - one operator of the computers and TV technique, and one meteorologist. Therefore, the meteosat imagery is being spread in almost real time to a very wide public. Similar SDUS-s were installed in two other places of CHMI (in prognostic center and at airport met. service).

PART IV System for satellite applications to meteorology and operationsl hydrology

4. PDUS (MDA, Canada, 1978) for NOAA/HRPT data, microprocessor based, not connected in-line to computer. Archives on 1600 bpi CCT, over-write period not less than 5 weeks. Selected cases archived without time limitation. Transmission of images to users via telephoto link. Several PCs for software development

(primary processing, applications), one of these connected to CCT tape-drive unit (enabling off-line processing of AVHRR/HRPT data). PC-based SDUS (3 stations) for Meteosat/WEFAX. One SUN (Spark 1+) workstation.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Connection of all PCs, NOAA PDUS and SUN workstation into one network. Processing of NOAA & HRPT data on SUN workstation in real time. Connection of the local network to Institute s data distribution network, distribution of processed satellite data via this network.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

None

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7.1 Publications

Hlavaty K. Sokol Z, 1991. Relation of cloud classification using combined spectral and textural features to the field of relative humidity. Proc. of the 5th AVHRR Data Users Meeting, Tromsoo, Norway

Setvak M. Doswell C.A., 1991. The AVHRR Channel & Cloud Top Reflectivity of Convective Storms. Monthly Weather Rev. 119, p. 841/847

7.2 Names and address

Eng. Petr Havranek - Head of the Satellite and Radar Department

Dr Martin Setvak - Head of satellite group, meteorological applications

Eng. Milan Folkman - technologist

Dr Karel Hlavaty - processing specialist, non-meteorological applications

Eng. Pavel Hampi - software specialist

all. Satellite and Radar Department
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DEMOCRATIC PEOPLE'S REPUBLIC OF KOREA

PART I Summary of the major highllights of research applications and operational changes

1.1 Satellite data receiving and processing systems were installed in 1990 at our service. In 1991, major efforts were directed to the development of algorithms and programmes based on the two different schemes, one of which had been proposed by Eyre (1989) and the other by Smith and Woolf, in view of applying them to the assimilation system of TOVS data in our meso-scale model. A series of inversion experiments have been carried out with artificially constructed data sets for the purpose of testing the performance of the schemes. A method of precipitation forecast using the imagery data of satellite was also developed.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 A programme was developed for inversion of TOVS data by Eyre's method (1989). It was tested with the data of a few standard atmospheres described in NESS 85. Taking these profiles as "true" ones and calculating the corresponding "observed radiances" through the radiation transfer equation, we introduced some error fields on them to get the initial guess fields and then the programme was run for examining the convergence to the "true profiles". The results of preliminary tests were encouraging. Two to three interactions seemed sufficient. When a sharp kind with different signs of the error was introduced, the scheme turned out to be unable to reproduce the "true profiles". In these cases relatively large errors remained at the few levels up and down to the corresponding level of kind. This may be attributable to the low vertical resolutions of satellite sounding data. The cloud amount, pressure at the cloud top and emissivity are not yet included in the scheme as parameters to be retrieved. Our feeling is that a lot of work has to be done in order to accomplish the programme.

2.2 A programme based on the scheme of Smith and Woolf was also developed. Comparative simulation experiments were carried out. It is far from being completed. Humidity profile was not retrieved satisfactorily.

2.3 Combined use of IR imagery data and upper air synoptic charts allowed us to manipulate an efficient method of estimating jthe rainfall amount. It is programmed and is ready to apply to weather forecasting. Unfortunately, the receiving systems are now appearing to be entirely unfit for operational use.

PART III A description of techniques development and applications of satellite data, derived products and services

Plans for future operational systems for satellite applications to meteorology and operational hydrology

3.1 New satellite data receiving and processing systems should replace the existing systems.

3.2 When the utility of the inversion scheme of TOVS is confirmed by a series of simulation experiments, it will be introduced into the data assimilation procedure in the meso-scale analysis and forecasting system.

ETHIOPIA

PART I Summary of the major highlights of research applications and operational changes

1.1 A new PC based PDUS/SDUS was installed and became operational in April 1990 at the Agency in Addis Ababa. This sytem has more capability and flexibility as compared to the previous satellite receiving systems.

1.2 PC based NOAA/HRPT station was installed and became operational at the NMSA, Addis Ababa for the first time in September 1991.

1.3 Installation of nine DCPs nation wide for the collection of meteorological data from the stations via meteosat in 1989.

1.4 Other than the traditional usage of satellite imageries for weather forecasting and analysis, a research project on rianfall and vegetaqtion monitoring using satellite data was started in April 1990 in co-operation with the U.K. Government (ODA).

PART II Major research and development in the application of satellite data, derived products and services

2.1 Rainfall estimation based on meteosat TIR data is being carried out using the methodology adopted from the University of Reading, U.K. The method starts with identification of cold rain bearing cloud (convective clouds) by simple temperature tresholding technique of the TIR images from meteosat. Linear regression models which relate cold cloud duration (CCD) to rainfall estimates for each summer months are already developed. Cold cloud duration and rainfall estimate maps for Ethiopiaan regions are being produced on a dekadal and monthly basis. These products which show rainfall amount and distribution in detail are being used to make more accurate rainfall assessment for early warning of drought, agrometeorology and hydrometeorology. Research work has continued to improve CCD/Rainfall Calibration parameters of the models to make more accurate estimates.

2.2 A study on surveying of crop, pasture and forest areas using vegetation index (NDVI) derived from NOAA/AVHRR data is being carried out. Maximum value composite maps of the LAC data are being produced regularly on a dekadal basis which shows distribution and condition of vegetation over the country. These products are found useful in assessing vegetation condition in growing seasons.

PART III A description of techniques development and applications of satellite data, derived from products and services

3.1 Forecasters have access to meteosat PDUS data sets for interactive processing using a PC which is connected to the main reception system. They are able to display, examine, enhance, animate, zoom, read temperature and overlay maps on satellite imageries from meteosat and NOAA using PC based image processing softwares (Autosat, TEKCOR) in near real time. These capabilities are found useful for meteorological analysis and forecasting. The Autosat and Tekcor softwares were developed by the University of Bradford.

3.2 University of Reading provided us with the algorithm for estimating rainfall using Meteosat TIR data. The software loaded in a PC captures and processes TIR data and creates CCD and rainfall files for a given period which are stored in the hard disk for later display and examination. Hardcopy printing of CCD and rainfall files with map overlays is also possible both in colour and black and white.

3.3 Interactive system for registration and processing in real time of AVHRR data obtained from NOAA satellites consists of:

- HRPT receiving station with semi automatic tracking horn antena;
- IBM-PC/386 PCs (two) connected to the receiver including VGA monitor, 100 MB hard disk and 16 MB RAM;
- Magnetic tape driver.

The software of the interactive system consists of programmes for:

- Computing of NOAA satellite positions (SAT SCAN);
- Registration of AVHRP data radiometric and geographical calibration (PC-Sharp);
- Processing of AVHRR data to compute NDVI (PC-Sharp) 10 days maximum composite NDVI images are stored on disks and tapes regularly and hard copies of these products are made available in colour.

PART IV System for satellite applications to meteorology and operational hydrology

PDUS Station

4.1 The PDUS receiver at the agency in Addis Ababa receives digital visible, infrared and water vapour imageries from meteosat on half hourly basis. This system started operation in April 1990. The received data are directly ingested in to a network of personal computers which have got 30 MB and above hard disk space and VCA monitor. Capturing processing softwares (Autosat, TEKCOR, Developed by the University of Bradford, U.K.) and rainfall estimator are installed in the PCs.

HRPT Station

4.2 Images from NOAA/AVHRR in all the five channels are received from daily overhead passes by the receiver system at the Agency in Addis Ababa.

4.3 Black and White hard copies of meteosat images are made available to the forecasters for TV weather presentation from the laser fax recorder at the Agency.

4.4 DCP Data from 9 remote observing stations in the country are being collected using the DCP system via meteosat.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 It is planned to acquire MDD receiver by the end of 1992.

5.2 The Rainfall and vegetation monitoring projects described in part I will be continued.

PART VI Validation and verification of satellite data and derived products used in operations including performance statistics

6.1 Preliminary validation of the dekadal rainfall estimates from meteosat TIR data for the 1991 summer months (June, July, August) against gauge recorded rainfall in a contingency table discriminates wet dekads and dry dekads with an average accuracy of 87%.

PART VII Other items (references, publications and names of scientists in charge etc.)

7.1 Contact can be made to the Agency on the following address:

National Meteorological Services Agency
P.O. Box 1090
ADDIS ABABA
Ethiopia

Tel: 512 299
Fax: 517 066
TLX: 214 74

7.2 Tadege, A. 1992: "Assessment of 1991 summer season rainfall as estimated by satellite over Ethiopia and some aspects of validation" paper presented at the International Workshop on Rainfall Estimation using Satellites, Niamey, 7-9 April 1992.

EUMETSAT

Introduction

EUMETSAT is an independent intergovernmental organisation created in 1986 to establish, maintain and exploit European systems of operational meteorological satellites and is governed by a Council with delegates from 16 members States (see below). The day to day activities of EUMETSAT are conducted by a Secretariat consisting, by mid 1992, of a Director with around 75 staff. The Headquarters of EUMETSAT is located in Darmstadt, Germany.

The primary motivation for the creation of EUMETSAT was the success of Meteosat, the European meteorological satellite developed by the European Space Agency (ESA). Meteosat-1 was launched in November 1977 and operated on behalf of the meteorological community by the European Space Operations Center (ESOC), an ESA establishment also located in Darmstadt. The follow-on satellite, Meteosat-2, launched in June 1981, provided routine images until 1988 when it was replaced by Meteosat-3. Incidentally, Meteosat-2 was removed from geostationary orbit in December 1991, at which time, it was still capable of image taking more than ten years after its launch. Meteosat-4, the first of a series of three satellites of the Meteosat Operational Programme (MOP) became the prime satellite following its launch in March 1989 and remains the prime satellite at the time of writing (July 1992). Meteosat-5 was launched in March 1991 and is the standby satellite, located a few degrees west of the nominal satellite. In the meantime Meteosat-3 has been moved to a position over the Atlantic at 50° West in support of a new mission called Atlantic Data Coverage (ADC).

The initial task of EUMETSAT is to ensure the continuation of the Meteosat satellite system by funding and administering the Meteosat Operational Programme (MOP). The operation of the MOP satellites and Meteosat-3 is also under the overall responsibility of EUMETSAT. ESA will continue to execute the Meteosat Operational Programme on behalf of EUMETSAT until the end of 1955. This means that ESA will continue to supervise the building and launch of the remaining MOP satellite and ESOC conducts day to day routine satellite operations. EUMETSAT makes policy and management decisions on present and proposed future satellite systems, provides all of the funding, and undertakes user liaison.

The Meteosat Operational Programme is funded until the end of 1995 and was the first major EUMETSAT activity approved by its Council. The Council has subsequently approved a continuation of the Meteosat programme beyond 1995 via the mechanism of a new programme called the Meteosat Transition Programme (MTP) which would include the launch and operation of at least one more Meteosat satellite, as a gap filler until the launch of the second generation Meteosat. In parallel with the development of the MTP, the Secretariat continues to be actively involved with preparations for Meteosat Second Generation (MSG), currently due for launch and operation from around the year 2000. Definition of the satellite system, including the imaging and sounding channels and data circulation is nearing completion. It is expected that ESA will actually develop the first satellite of the series. EUMETSAT is also involved, with ESA, NOAA, NASA and other international agencies, in preliminary studies concerning a series of European meteorological polar orbiting satellites, also due for launch in the late 1990's. EUMETSAT will, in addition, develop and implement its own ground station systems to support all new satellite programmes.

PART I A brief summary of the major highlights of research applications and operational changes.

Meteorological Operations

1.1 The dissemination of imagery and the derivation of meteorological products from Meteosat-4 continued throughout 1991 according to an agreed schedule and with negligible interruption in services. With effect from 1 August 1991

Meteosat-3, located at 50° West, commenced the Atlantic Data Coverage mission, whereby a mixture of digital high resolution and analogue WEFAX images are regularly broadcast on a single dissemination channel.

1.2 Various modifications to data processing software have been introduced in recent years to reduce the negative speed bias of high level cloud track winds and results have generally shown a significant improvement in the quality of the data. Additional automatic quality control of winds based on horizontal wind gradient checks commenced on 4 February 1992.

1.3 The extraction of water vapour winds has been carried out on an experimental but regular basis since mid 1991. These winds are regularly transmitted to the European Centre for Medium-range Weather Forecasts (ECMWF) for validation and data impact studies.

1.4 The production of ESOC Precipitation Index (EPI) and ISCCP data sets are also fully automatic. There is a routine archive of all these products in ESOC.

PART II A description of the major research and development in the applications of satellite data, derived products and services.

Sea Surface Temperature

2.1 A new scheme to derive sea surface temperatures from imagery on an hourly basis began on 2 May 1991. The intent of this scheme is to reduce the effects of partial cloud contamination in sea surface pixel clusters by using spatial coherence information.

Cloud Motion and Water Vapour Winds

2.2 Automatic quality control of cloud motion winds based on horizontal wind gradient checks has been carried out since 4 February 1992. This procedure eliminates wind vectors in error because of a computation of an average vector for too large an area resulting in a lower windspeed. This source of error is frequently encountered in regions of strong horizontal wind shear. Vertical gradient checking will be tried in the near future.

2.3 Software has been developed for the extraction of Water Vapour (WV) channel winds, in parallel with the operational cloud motion wind extraction scheme. These winds are transmitted twice a day to ECMWF for validation and to assess their impact upon numerical weather prediction schemes. Preliminary results suggest that upper level WV winds will have less negative speed bias than winds from the same "cloud" targets in the Infra-Red (IR) channel and the number of WV winds produced is significantly larger. Medium level winds which have been allocated pressure heights greater than 400hPa (i.e. lower in the atmosphere) are automatically deleted from the data set prior to distribution because they indicate a lower quality than those WV winds at the higher levels.

2.4 The investigation of a scheme for the extraction of cloud motion winds from Visible (VIS) channel data has continued throughout 1992. The main emphasis will lie with the extraction of low level winds with a fixed height assignment, similar to the scheme adopted by NOAA.

2.5 A study of the possibilities for improved cloud motion tracking and height assignment from high Cirrus clouds began in 1990 and is expected to be completed later in 1992.

2.6 A Workshop on cloud motion winds was held from 17 - 19 September 1991, sponsored by EUMETSAT, NOAA and WMO. The proceedings have been published as EUMETSAT document reference number EUM P 10. One important outcome of this Workshop was an agreement that there should be closer cooperation in the fields of product quality control and in the use of WV channel information from cloud tracking and height assignment.

2.7 At the present time all Meteosat products are distributed via the GTS in SATOB code. After 1995 there will probably be a change to the more efficient BUFR code. Since the SATOB coding does not allow the discrimination of satellite winds extracted from data from two different spectral channels from the same satellite, a modification to the code has been requested following a recommendation made jointly by ECMWF and EUMETSAT. The more general distribution of WV winds will commence once the relevant modifications to the code have been agreed.

Radiative Flux Divergence

2.8 A feasibility study for calculating the cloud generated radiative flux divergence from Meteosat imagery was initiated in 1989 and is expected to be completed later in 1992.

Precipitation Index (PI)

2.9 There remains a strong interest in this index for a wide variety of climatological purposes, studies on general circulation, agrometeorological applications and forecast model verifications.

2.10 The ESOC PI (EPI) has been formulated in order that it should be comparable with those used by other satellite operators, in order to obtain a globally meaningful product. The index should be produced with minimum human intervention and data processing should be similar to that used in the determination of other meteorological products.

2.11 Consequently, the formulation by Arkin (1979) was considered the most appropriate and it was generally agreed that this type of index would be used for the Global Large-Scale Precipitation Data Sets for the World Climate Research Programme.

2.12 The index developed at ESOC has a horizontal resolution of about 1.5° x 1.5°, compared to a value of 2.5° x 2.5° used by NOAA. Secondly, the upper tropospheric humidity product derived from the WV channel is also stored, since it may be a useful parameter in the determination of actual precipitation (Adler and Mack, 1984). Precipitation index is archived on magnetic tape and four or five tapes are required for one year of data.

ISCCP Activities

2.13 As a participant in the World Climate Research Programme ESOC continues to perform the functions of a sector processing centre within the overall data flow scheme of the International Satellite Cloud Climatology Project (ISCCP). The archived ISCCP data sets consist of Meteosat image data sampled at the following resolutions:

- B1 data set 10 km resolution
- B2 data set 30 km resolution

2.14 The data are sampled at three hourly intervals (main synoptic hours) and visible image pixels are averaged to match infra-red pixel resolution. Either four days of B1 data or one month of B2 data can be stored on one 6250 bpi magnetic tape. B1 data is retained for five months and B2 data indefinitely.

PART III A description of techniques, developments and applications of satellite data, derived products and services.

Technical improvements for Operational METEOSAT

3.1 The MOP satellites provide simultaneous transmission of visible data at full resolution, infrared and water vapour channel data, and each channel output is coded in eight bits instead of six bits originally used for visible and water vapour. In addition, a four-channel 2400 bit/sec data relay capability has be added to the main satellite transponder, designed to support the Meteorological Data Distribution (MDD) mission. With this mission alphanumeric and graphic meteorological information uplinked from Rome (Italy) and Bracknell (UK) respectively, are regularly relayed to Africa and surrounding regions.

PART IV Description of the satellite system in operational use in 1992.

4.1 The reader should note that a full description of the Meteosat satellite system is described in WMO Publication No. 411. The use of METEOSAT-3 for the ADC Mission is described in WMO letter No. S/MS/GEO of 24 September 1991 which was mailed to all WMO Permanent Representatives and Presidents in Regional Associations I, III, IV and VI.

PART V Plans for future operational systems of satellite with applications for meteorology and operational hydrology.

5.1 Meteosat Transition Programme (MTP)

5.1.1 Introduction

In November 1990 the EUMETSAT Council agreed to establish the METEOSAT Transition Programme (MTP), to bridge the gap between the end of the METEOSAT Operational Programme (MOP) in 1995 and the start of METEOSAT Second Generation (MSG). It was further decided to implement the programme in two phases:

The first phase would include the manufacture of one new satellite, advance procurement activities for a possible second satellite, definition of the ground segment and programme management.

The second phase would include the implementation of the ground segment, the satellite launch and the operation of space and ground segments for 5 years.

By the end of 1991, most of the industrial contracts were negotiated and full go-ahead was given to the satellite prime contractor (Aerospatiale) and to the equipment suppliers. Advance activities for a second satellite were authorised to start in November 1990.

The definition of the various MTP ground segment elements was still in progress at the end of 1991. The total system will support the following main functions:

- data reception at the ground station
- image processing and dissemination
- meteorological product extraction
- data archive and retrieval
- DCP processing and management
- satellite and mission control
- ground communications.

The operational phase for MTP will start at the beginning of December 1995, after expiry of the MOP agreement with ESA, and it is expected that the programme will continue for a period of 5 years.

5.2 Meteosat Second Generation

5.2.1 Introduction

During 1991 EUMETSAT established a Preparatory Programme for METEOSAT Second Generation (MSG) which will define the total space and ground system. This preparatory programme, which is being carried out in cooperation with ESA, will lead to a main development starting in 1994. The launch of the first flight model is foreseen in the 2000 time-frame. Three other satellites will follow, in order to ensure twelve years of continuous operations.

The current status of the programme can be summarized as follows:

a) the MSG spacecraft will rely on a spin-stabilized platform carrying a main imaging radiometer, a meteorological communication package (MCP) and an additional payload of experimental instruments and/or a Search & Rescue beacon,

b) the Spinning Enhanced Visible and InfraRed Imager (SEVIRI) will include three sets of channels:

   i seven VISIR channels, with a sampling distance of 3km at ssp and a repeat cycle of 15mn on the whole disk.

   ii six channels in the water vapour and carbon dioxide absorption bands, similar to those used on the existing METEOSAT imager and GOES VAS, these channels having the same sampling characteristics as those under i)

   iii a high resolution visible broad-band channel with a sampling distance of 1 km at ssp and 15mn repeat cycle, mainly covering the European area

c) the dissemination of data and products to the user will rely on the same frequency bands as for MOP, and will be based on internationally agreed HRIT and LRIT formats already defined within the CGMS.

5.2.2 MSG missions

The Main missions of METEOSAT Second Generation will be:

a) Basic multispectral imagery, with better spectral, spatial and temporal resolution than the existing METEOSAT satellites, mainly in support of nowcasting and short-range weather forecasting

b) High resolution imagery, by observing the Earth in the same visible band as METEOSAT, with a spatial resolution similar to the AVHRR instrument and in support of mesoscale phenomena monitoring over Europe

c) Air Mass Analysis, using some H_2O and CO_2 absorption channels and whose usefulness for nowcasting has been demonstrated from VAS experience

d) Meteorological Product Extraction (winds, surface temperatures, etc.) upgraded according to the improved capability of the imager.

e) Support to Climate and Environment monitoring, as well as to Earth resources management

f) Continuity of METEOSAT data collection and dissemination missions.

The MSG imager will allow a "three-dimensional" view of the Atmosphere from the geostationary orbit. This objective is coherent with that of NOAA, who are developing the GOES-Next series, and which will embark an imager and an independent sounder, on a three-axis stabilized platform, currently scheduled to start operations in 1994.

5.2.3 SEVIRI characteristics

The baseline concept of SEVIRI can be considered as a combination of three separate instruments in one single imager (see next page).

MSG SEVIRI CHARACTERISTICS

Bands	Name	Limits (mm)
VIS	HRVIS	0.50 - 0.90
&	VIS0.6	0.60 - 0.67
NIR	VIS0.8	0.77 - 0.89
	IR1.6	1.56 - 1.70
Window	IR3.7	3.5 - 4.0
	IR8.7	8.5 - 8.9
	IR10.8	10.3 - 11.3
	IR12.0	11.5 - 12.5
Water	IR6.2	5.7 - 6.7
vapour	IR7.3	7.1 - 7.6
Ozone	IR9.7	9.69 - 9.82
Carbon	IR4.5	4.47 - 4.57
dioxide	IR13.4	13.2 - 13.6
	IR14.0	13.8 - 14.2

The three instruments in one are thus :

a) VISIR, with a slight different definition of the channels, better adapted to the satellite, with a coarser spatial resolution (3km at nadir) but providing data with a repeat cycle of 15mn.

b) An air mass monitor with six channels, two in the water vapour absorption band, as a continuation of MOP, three in the carbon dioxide band, coming from VAS and one in the ozone absorption band (9.7mm), operating with the same spatial and temporal resolutions as the imaging channels.

c) A High Resolution VISible imager (HRVIS), with a sampling distance equivalent to the polar orbiting VIRSR (1km at nadir), providing images with the 15mn basic repeat cycle.

The main characteristics of SEVIRI will be the simultaneous operation of all channels with the same sampling characteristics. It will provide users with improved accuracy imagery and products (winds, surface temperatures, etc.) but also with new information on atmospheric stability.

5.2.4 MSG Data dissemination and archive

For real-time access to the imaging radiometer data, the main need is for level 1.5 data and may be summarized as follows:

* the image data shall be navigated, meaning images have been recti-

fied and Earth located, prior to dissemination

- the image data shall be calibrated, in order to be directly used without any further radiometric correction (except probably VIS channels)
- the image data shall be quality-controlled and flagged, for more efficient use,
- the image data shall be disseminated with a minimum delay for each application, i.e. "as soon as possible" for nowcasters, and not later than two hours after acquisition for numerical forecasters

The result of these requirements is the need for a dedicated Meteorological Communication Package (MCP) as part of the satellite payload. Such an MCP will be implemented both on MSG and EPS alike, with different constraints, according to the nature of the satellite and to the main user categories.

Such dissemination schemes already exist in the present system. The basic objective of meteorological satellite operators for the next decades is to upgrade the service performed by ensuring a better coherence between data coming from the geostationary and from the polar orbiting satellites. This supposes that there will be a definition of dissemination schemes for digital data, using common protocols and formats. The definition process has been already initiated within CGMS, and the goal is to provide the users with three types of services :

1. High Resolution Service including all available level 1.5 image data, for the users needing full information and able to derive various products from it,
2. Low Resolution Service including a selection of images from the most important channels (visible and window), with a reduced spatial resolution, to be acquired with relatively simple stations, for users requiring only a few applications,
3. Global Data Service, including the full set of data and some centrally derived products for users performing global applications, with particular attention to numerical weather forecasting

It is obvious that the implementation of these three schemes is quite different for the two categories of spacecraft, but imposes the definition of a central processing facility and of transmission systems, which, for the geostationary satellite, relies on the spacecraft itself.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics.

6.1. Overall performance 1991

Month	Image Acquisition	Image Dissemination	Data Collection
January	99.5	98.9	98.8
February	98.2	98.9	98.8
March	89.9	97.4	98.4
April	99.3	98.9	98.2
May	98.9	98.2	98.5
June	99.4	99.3	98.9
July	99.6	98.8	98.6
August	99.4	99.7	98.2
September	99.2	99.3	98.4
October	98.1	99.0	98.8
November	99.4	98.5	98.1
December	99.3	99.6	98.6

Percentages indicate the performance achieved in relation to a ground segment with 100% availability.

6.2 Data Collection Mission

The status at 31 December 1991 was:

DCPs admitted: 846
DCPs reporting during December 1991: 350
Approximately 114044 DCP messages were received during December 1991 of which 50399 were routed to the GTS.

6.3 Meteorological Information Extraction Performance

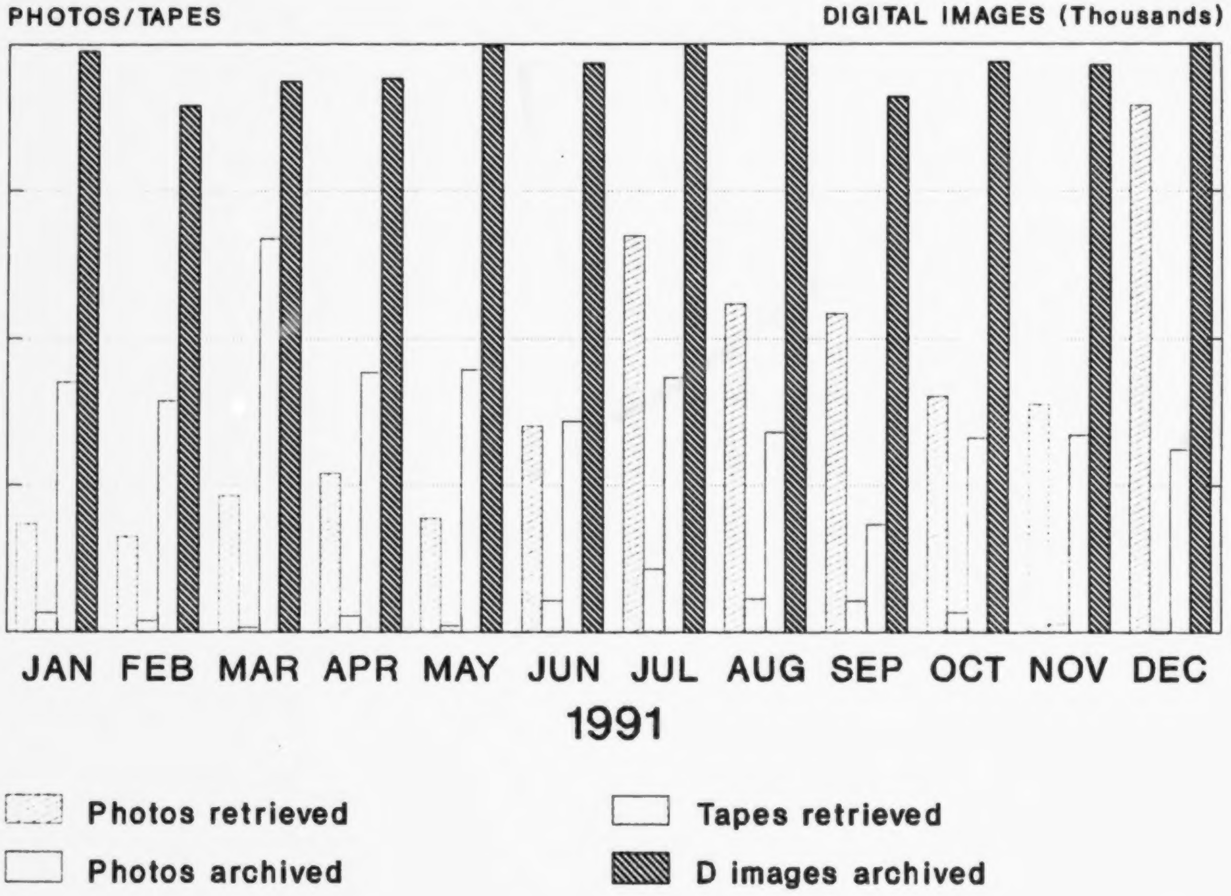
The production and dissemination of products in 1991 was:

	Cloud Motion Vectors (CMV)	Sea Surface Temp. (SST)	Upper Tropospheric Humidity (UTH)	Cloud Analysis (CA)	Cloud Top Height (CTH)
January	100	100	100	100	99.2
February	99.2	100	100	100	99.1
March	100	100	100	99.2	97.6
April	100	100	100	100	100
May	100	100	100	100	100
June	100	100	100	100	100
July	100	100	100	100	99.2
August	100	100	100	100	100
September	100	100	100	95.8	100
October	100	100	100	100	100
November	100	100	100	100	99.2
December	99.2	100	100	100	99.2

Note

1. Figures indicate the percentage of products distributed against a theoretically perfect system.

4. Meteosat Data Service and Archive Performance - 1991



PART VII Other items (references, publications and the names of scientists in charge, etc.)

1. EUMETSAT PUBLICATIONS

A range of documents are available from EUMETSAT. These include EUMETSAT publications, Technical Documentation prepared by ESA and publications such as the proceedings of workshops, etc. The titles available in 1991 include:

a) EUMETSAT Brochures (Price Code A)

EUM BR01	EUMETSAT; The European Organisation for Meteorological Satellites
EUM BR02	EUMETSAT Missions and Services

b) EUMETSAT Technical Documentation (Price Code B)

EUM TD01	Meteorological Data Distribution (MDD) User Manual, Part 1, Technical Description

c) Technical Documents produced by ESA (Price Code C)

EUM001	Introduction to the Meteosat System
EUM002	Meteosat WEFAX transmissions
EUM003	Meteosat High Resolution Image Dissemination
EUM004	A Meteosat Primary Data User Station
EUM005	Meteosat Data Collection System
EUM006	Meteosat DCP Re-Transmission System
EUM007	MIEC Processing (of meteorological products)
EUM008	Meteosat Data Service Brochure
EUM009	Meteosat Magnetic Tape and File Description
EUM011	Catalogue of Digital, Photographic and Meteorological Data

d) Monthly Image Summary, produced by ESA (Price Code D)

EUM010	Meteosat Image Bulletin (monthly, contains daily image examples)

e) EUMETSAT Proceedings of Conferences/Workshops (Price Code E)

EUM P01	The 6th Meteosat Scientific Users' Meeting, (Amsterdam, 25-27 November 1986)
EUM P02	Workshop on Satellite and Radar Imagery Interpretation (Reading, UK, 20-24 July 1987)
EUM P03	Satellite Meteorology and its Extension to Agriculture (Erice, Sicily, 13-20 November 1987)
EUM P04	The 7th Meteosat Scientific Users' Meeting (Madrid, 27-30 September 1988)
EUM P05	The 1st EUMETSAT Legal Workshop, on the Protection of Satellite Images (Darmstadt, 13 -14 March 1989)
EUM P06	The 4th AVHRR Data Users' Conference (Rothenburg, Germany, 5-8 September 1989)
EUM P07	Workshop on the use of Satellite Data Nowcasting and Very Short Range Forecasting (Reading, UK, 16-20 July 1990)
EUM P08	The 8th Meteosat Scientific Users' Meeting (Norrköping, Sweden 28-31 August, 1991)
EUM P09	The 5th AVHRR Data Users' Meeting (Tromso, Norway, 25 - 28 June 1991)
EUM P10	Proceedings of the Wind Workshop (Washington D.C., USA, 17-19 September 1991)

f) EUMETSAT ANNUAL REPORTS (Price Code F)

EUM AR01	EUMETSAT ANNUAL REPORT 1986/1987
EUM AR02	EUMETSAT ANNUAL REPORT 1988
EUM AR03	EUMETSAT ANNUAL REPORT 1989
EUM AR04	EUMETSAT ANNUAL REPORT 1990

g) CO-ORDINATION OF GEOSTATIONARY METEOROLOGICAL SATELLITES (Price Code G:

CGMS 01	Consolidated Report of CGMS Activities (8th Edition, April 1989)
CGMS 02	International Data Collection System Users' Guide (6th Edition, January 1988)
CGMS MR16	Report of the 16th Meeting of the CGMS, (Washington, DC, 28 September 1987 - 2 October 1987)
CGMS MR17	Report of the 17th Meeting of the CGMS (Darmstadt, 3-7 October 1988)
CGMS MR18	Report of the 18th Meeting of the CGMS (Geneva, 13-17 November 1989)
CGMS MR19	Report of the 19th Meeting of the CGMS (Tashkent, 10-14 December 1990)

h) SPECIAL PUBLICATIONS

EUM BR03	EUMETSAT Directory of Meteorological Satellite Applications - Ring bound version (includes registration and updates) PRICE DM 100 - Spiral bound version PRICE DM 90

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All these documents may be obtained from EUMETSAT. To order, please write, enclosing the correct remittance where appropriate and stating if the English or French version is required.

2. ADDRESSES

Overall responsibility for EUMETSAT programmes:

The Director
EUMETSAT
Am Elfengrund 45
6100 Darmstadt-Eberstadt
Germany

Authority in responsible for the distribution of Meteosat imagery and data tapes, on behalf of EUMETSAT:

Meteosat Exploitation Programme - Data Service
European Space Operations Centre
Robert Bosch Strasse 5
6100 Darmstadt
Germany

FINLAND

Finnish Meteorological Institute

PART I Summary of the major highlights of research applications and operational changes

1.1 Both image data from geostationary and image/sounding data from polar orbiting satellites are received and processed for operational and research purposes. A PDUS receiving system for Meteosat data has been working operationally since 1986 and the images are processed in real time. A separate receiving and processing system for NOAA HRPT data has been available since 1987. Meteosat images and NOAA AVHRR images are also transferred to the Meteorological workstation, where they can be displayed together with conventional observations. These workstations are also used in regional forecasting offices. NOAA AVHRR images can only be viewed within the processing system in the central office. Sounding data are routinely processed and temperature/humidity profiles calculated.

PART II Major research and development in the applications of satellite data, derived products and services

Satellite Soundings

2. The satellite sounding processing system is designed so that when the full satellite pass is ready the TIP data are transferred directly to CRAY-XMP of the Centre for Scientific Computing, where the preprocessing steps as well as the inversion to a full temperature and humidity retrievals are carried out. Soundings are solved for each line and for each spot using the ITPP software from Wisconsin. The aim is to use the soundings (or raw radiances) in the data-assimilation step of the limited area forecasting system (HIRLAM). Since it seems to be difficult to prove the usefulness of satellite sounding data in improving the quality of forecasts at least in data dense areas, priority is given for the evaluation of brightness temperature "images" in synoptic use. A software package has been developed to view the products and comparisons to the radiosonde data are made. Animation of products is also included.

PART III Description of technique development and applications of satellite data, derived products and services

3.1 Precipitation estimations derived from weather satellite imagery:

Both NOAA AVHRR (Advanced Very High Resolution Radiometer) and Meteosat HR (High Resolution) data is used to estimate rainy areas and instantaneous rainfall. Method for Meteosat HR analysis has been developed in ESOC (European Space Operational Centre), Canadian Service de L'Environment Atmospherique and FMI based on results from SMHI (Swedish Meteorological and Hydrological Institute) and FMI. All five spectral channels of the AVHRR data are used to find those clouds, which give rain, and the instantaneous rainrate class is then decided by using the numerical 6 hour temperature prediction fields (HIRLAM High Resolution Local Area Model) as thresholds.

3.2 Cloud classification

FMI and HUT (Helsinki University of Technology) have a project to develop a automatical method to classify clouds from AVHRR imagery by using neural network classifiers. After two years of research on this topic, main classes (low, middle and high clouds) can be separated with processing time being acceptable for the operational use of the results.

PART VII Other items (references, publications and names of scientists in charge etc.)

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FRANCE

METEO-FRANCE

PART I SUMMARY OF HIGHLIGHTS

SCEM Toulouse :

1.1 The main event in 1991 was the move from Paris to Toulouse (the distance between these towns beeing over 700 km or 425 miles) of the operational main part of our service (Service Central d'Exploitation Météorologique), including large scale forecasters, teams in charge of design and maintenance of NWP models, specialists in satellite data processing, telecommunication branch and computing main facilities. The transfer of operational responsability happened on September 12, 1991 without service interruption.

1.2 Due to that move we had only a few new actions in 1991 concerning satellite data. For more details, please refer to the 1990 report and to the NWP reports.

CMS-Lannion :

1.3 On behalf of EUMETSAT CMS-Lannion acquires, rectifies and processes METEOSAT-3 raw data each hour since August 1, 1991, in order to disseminate WEFAX images (160 a day) for users of METEOSAT-ADC (Atlantic Data Coverage).

1.4 Special METEOSAT-ADC formats are also disseminated in parallel via the nominal METEOSAT.

1.5 Since August 1, 1991, CMS-Lannion processes and disseminates via METEOSAT-4 special formats from NOAA/AVHRR data on the European area (cloud classification and Channel 3 data in stereographic projection).

1.6 Elaborate images are available for various users via the french ISDN network (NUMERIS) : Television companies, meteorological centers, Navy center, ...

PART II MAJOR RESEARCH AND DEVELOPMENTS

II-1 Cloud classification with AVHRR

A cloud classification, based on threshold tests, is operationally applied to the nighttime NOAA-11 AVHRR imagery and to the evening NOAA-12 AVHRR imagery (only when the sun is below the horizon). Up to eight cloud types are defined. A final four-bit image covering France is then obtained and operationally delivered to all french forecasters through the Meteotel network at the same scale and projection as METEOSAT images for combined use. (Derrien, LeGléau (CMS Lannion))

II-2 Cirrus study with NOAA-AVHRR

CMS has developped a method to compute thin cirrus top temperature from NOAA-AVHRR imagery by adjusting a curve on the 11μm/11μm-12μm histogram. This method has been validated on the North Sea during the international ICE 09 experiment ; satellite derived cirrus temperatures compare within 5°C with aircraft and lidar measurements. (Derrien, Lavanant (CMS Lannion))

II-3 Cloud classification with METEOSAT data

An operational cloud classification method has been defined for application to METEOSAT data. It is based on a clustering technique applied on time cumulated histograms. Up to 16 cloud types, ranging from cloud free surface to high thick clouds can be identified. (Le Borgne, Marsouin (CMS Lannion))

II-4 Use of sounder-imager synergy for short range forecast

Two thickness (1000hPa-700hPa and 1000hPa-500hPa) and the corresponding temperature are daily retrieved from the NOAA-TOVS sounder data with ITPP-3 algorithm. The resulting fields covering the Lannion Acquisition Area are daily sent to the Central Forecast Center in Toulouse (France), superimposed to AVHRR multispectral colour composite images. (Rochard, Quere (CMS Lannion))

II-5 Fast radiative transfer algorithm

CMS has generated the needed polynomial transmittance coefficients internal to RTTOVS (fast radiative transfer model developped at ECMWF) with atmospheric transmittances calculated by using the FASCOD2 line-by-line model. The FASCOD2 computations are made for a small set of earth representative profiles, uniformly mixed-gases and water vapor molecular species separately, and for different scanning angles and pressure levels.

A transmittance storage at a medium frequency resolution is also tested. This would allow afterwards any filter convolution of the transmittance and a quick adaptation of the RTTOVS model for any new channel. (Rochard, Lavanant, Brunel (CMS Lannion))

II-6 Operational retrieval of fine scale Sea Surface Temperature from AVHRR data

Fine scale (2 km resolution) Sea Surface Temperature (SST) maps have been produced and analysed daily at CMS since 1979. This activity aimed to meet the French Navy requirements, to provide the oceanographers with climatological or near real time information and occasionally to support tuna fishing campaigns. The retrieval algorithm was improved in 1991 to account for satellite zenith angle effects. (Le Borgne, Marsouin (CMS Lannion))

II-7 Surface radiative flux retrieval from METEOSAT data

Our objective is the retrieval of radiative surface fluxes at small or mesoscale, in real time, over Europe, North-East Atlantic and the Mediterranean Sea. Solar irradiance maps have been routinely produced on a hourly basis since 1988. A method for calculating the downward longwave irradiance from METEOSAT derived cloud types and forecast model outputs has been defined and tested. (Le Borgne, Marsouin (CMS Lannion))

II-8 Vegetation mapping using Meteorological satellite

NDVI maps covering western Europe have been daily computed from NOAA-11/AVHRR imagery since 1990. The use of a clustering algorithm has allowed the distinction of 20 different NDVI temporal behaviours. Nearly all the classes can be qualitatively explained by the percentage of winter and summer crop, forest, grassland and vineyards, when compared to a vegetation survey done by the French Agriculture Department. This vegetation map is the first step toward a vegetation description which will be needed for the parametrisation of the energy and water budget over the continental surfaces in the ARPEGE METEO-FRANCE NWP model. (Le Gléau, Derrien (CMS Lannion))

II-9 Ozone detection

At the end of 1991 and the beginning of 1992, an experimental compaign for ozone observation took place in Diruna (Sweden). Satellite data have been intensively used, especially TOVS/HIRS2 and TOMS data which have been compared. Ozone maps were deduced from these data (F. Karcher, SCEM Toulouse)

II-10 Fog detection

METEO-FRANCE, CNRS (National Center for Scientific Research) and Région Nord-Pas de Calais have joined their forces for improving significantly fog prediction and detection. A major scientific work has been done, including various aspects (numerical models ...). A new method has been developed for fog teledetection, by day or by night, using a combination of AVHRR channels. (SCEM Toulouse)

PART III TECHNIQUES DEVELOPMENT AND APPLICATIONS

Lider and Kalman filter :

3.1 A prospective study has been led in relation to the satellite-borne lidar project (American project LAWS). This study used in particular the "Kalman filter" application of the ARPEGE project whose development has been continued. The experiments have been carried out at low resolution in order to allow the explicit computations of the error covariance matrices.

SST analysis

3.2 Experiments have been carried out on the use of the NOAA AVHRR data (received in Lannion) in the SST analysis.

PART IV SYSTEM IN CURRENT OPERATIONAL USE

4.1 No major change in our operational use of satellite data in 1991 (see the 1990 report for details). The main features are :

- use of TOVS SATEM 500 in the analysis scheme of our global model EMERAUDE

- use of raw TOVS radiances in our limited area model PERIDOT

4.2 Like other NWP centers, we decided to stop the use of TOVS SATEM 250 in data assimilation schemes, after detection of a coding error.

Two polar orbiting satellite (NOAA11 and NOAA12) and three geostationnary satellites (METEOSAT-4 at 0°W position, METEOSAT-3 at 50°W, abd GOES-7 at 110°W relayed by GOES-2 at 60°W) are received daily at the CMS. All acquisitions and processings are started without any operator intervention. The various processings are briefly described below.

NOAA processing :

About twelve NOAA orbits are received each day and data of the Advanced Very High Resolution Radiometer (AVHRR) and of the Tiros Operationnel Vertical Sounder (TOVS) are processed according to the following scheme.

At first, raw data are calibrated and navigated and a cloud classification and navigation adjustement are performed on AVHRR images. A second stop includes remapping of 4 to 6 AVRR channels onto a stereographic grid and extraction of physical parameters such as cloudiness and cloud top temperature.

The results are disseminated to meteorological users : images for nowcasting and physical parameters as input to numerical weather forecasting model.

Sea surface temperature maps at 2 kms resolution are produced after analysis of AVHRR images on an interactive console.

METEOSAT-4 processing

The 48 high resolution B format images are received and processed daily. After acquisition and calibration, stereographic images in the 3 channels are delivred to METEOFRANCE users. Some special products for television are also processed and delivered by Ethernet link to an ISDN server. Maps of solar irradiance at the Earth surface are calculated routinely with a one hour resolution.

24 high resolution A format images (one each hour)are processed to obtain rainfall estimations and sea surface maps in the tropical regions. The A format of 12H UTC ios used to produce a multispectral colour-composite image for television companies.

METEOSAT-3 processing

The METEOSAT 3 raw data are acquired each hour and rectified into nominal images. Various sectors corresponding to L and X formats are extracted in VIS , IR and WV images. For each sector, a contrast enhancement is made and grids, coastlines and annotations are added to the images. All sectors are transmitted to the GOES Meteosat Relay (GMR).

The GMR send analogic data to METEOSAT-3 and METEOSAT -4 and digital data to METEOSAT-4, LX, LR, LY and X formats are transmitted to METEOSAT-4 overy 3 hours. Other L Wefax formats are transmitted to METEOSAT-3 every hour.

GOES processing

Acquisition of GOES AAA is possible on request. After navigation, calibration and eventually windowing, the data are remapped onto a geographical grid (which is usually cylindric or mercator, depending on the users's request) and delivered to workstations.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS

Short term (1992/1993)

* Operational use ozone maps derived from TOVS HIRS data. The inversion algorithm has be written by the CNRM (National Center for Meteorological Reseach). The ozone maps will be produced every day and cover the atlantic ocean. They are very useful for the forecasters, showing clearly cold air/warm air boundaries on oceanic regions, where conventional observations are quite uncommon.

* Introduction, in the analysis scheme of our new NWP model ARPEGE, of TOVS 120 km retrievals produced by NOAA/NESDIS and coded in BUFR.

Long term (after 1993)

* Introduction, in the future 3D and 4D variational analysis scheme, of raw TOVS radiances. This direct assimilation of satellite data should be more efficient than the assimilation of temperature and humidity retrievals, which is not optimal.

In the context of collaboration with the French loaboratory CRPE, a technique for using the SSM/1 data in the humidity analysis has been validated.

This study will go on in the context of the 3D variational analysis component of the ARPEGE project.

* In order to prepare the "IASI" instrument (which must be a part of the future European Polar platform), a study was carried out on the information content of the future instrument: this information content has been quantified for some meteorological parameters (e.g. temperature) using covariance matrices, from realistic assumptions on the raw measurements and on the physical model linking the measurements to the meteorological parameters.

PART VI VALIDATION AND VERIFICATION

ERS-1

Since the arrival of the first ERS1 data (launched on July 16th), Météo-France has worked on the validation and the calibration of these data, in collaboration with other meteorological centres (e.g. : ECMWF, UK Met Office). (C. Gaffard)

TOVS data

In september 1991, a new team has been created in Météo-France, in charge of monitoring the various data that enter in assimilation schemes of numerical models. Satellite data (especially TOVS data) are a large part of the future work of that team, due to the continuously increasing proportion of satellite data in such schemes (contact point : B. Lacroix).

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GERMANY

Deutscher Wetterdienst, Offenbach

PART I SUMMARY

1.1 Full operational processing of digital METEOSAT and NOAA data continued with a PDUS and HRPT system which was been taken into operation one year before. An experiment has started very successfully to transmit processed digital satellite data from the central office in Offenbach to a workstation at a regional forecasting office by means of a digital public data link.

1.2 Research applications concentrated on:

- further improvements in TOVS data processing
- support in the development of methods for deriving atmospheric humidity parameters from microwave satellite data
- elopment of a method for determination of the 3-dimensional cloud field from satellite data in combination with conventional ground-based data
- precipitation estimates from satellite image data

PART II RESEARCH AND DEVELOPMENT

2.1 TOVS Data Processing

Vertical temperature profiles are inverted from direct received TOVS data regularly by means of the ITPP-3 (International TOVS Processing Package) which had been provided earlier by the Cooperative Institute für Meteorological and Satellite Studies (CIMSS), University of Wisconsin. Regression techniques had been applied to determine the first guess for the inversion process. Comparisons with NOAA-SATEM data and radiosonde measurements indicated a somewhat larger systematical and casual error, especially in the tropopause levels. First steps have been taken in order to use forecasts from the mesoscale 'Europa-Modell' of the Deutscher Wetterdienst as first guess in the retrieval process. Further efforts in improving the quality of TOVS data inversions and studies on their impact in NWP are intended for the following year. The TOVS data are not only used for retrievals of temperature and humidity profiles, but also for experimental mapping of total ozone distribution and instability parameters (Böhm).

A cooperation has been continued with the University of Karlsruhe (Fischer/Olesen/Sun) for collocation of NOAA-AVHRR and TOVS data for a more accurate assessment of cloudiness in TOVS pixels and its impact on the retrieved temperature and humidity profiles. In addition, the co-processing of TOVS and AVHRR data will be used for assignment of quality flags to each retrieved profile from TOVS-data (Olesen, Böhm)

2.2 Humidity Parameters from Microwave Data

The cooperation with the Kiel University (Ruprecht, Simmer, Wagner et. al.) has been continued; purpose of this cooperation is the determination of atmospheric humidity parameters (vertical profiles for 20 layers, total water content, total liquid water content) from microwave satellite data (SSM/I) over sea by means of EOFs (Empirical Orthogonal Functions). Specific activities in 1991 were:

- a detailed study on all factors influencing the determination of the atmospheric humidity parameters and their significance and impact in the derivation process.

- tests of strategies for the assignment of quality flags by using concrete SSM/I data sets.

  One highlight of the results of both these studies is that the accuracy of the total water vapour content is mainly influenced by the water vapour concentration itself (remote sensing error proportional to the water vapour content); The greatest significance has to be assigned to the water vapour content in the planetary boundary layer.

- studies on dependencies of the EOFs on geographical areas and meteorological conditions. It turns out that the EOF analyses result best to correlations with radiosonde measurements when both sea surface temperature and total water vapour content together are used as selection and input parameter criteria.

- studies on possible improvements in the accuracy of humidity profiles from the future AMSU instruments by means of the EOF method. This resulted in ideas for combining iterative methods with the EOF method. There are several promising approaches which have to be studied further. (Ruprecht, Simmer,Wagner)

2.3 3-Dimensional Cloud Fields

Testing has begun on a method which has been developed to derive the 3-dimensional cloud field from satellite data and conventional ground-based data (SYNOPs). Cloud recognition and classification is performed by bispectral METEOSAT image processing; information on cloud base, thickness and layers are derived from the SYNOP data. The method will be further developed for NOAA-AVHRR multispectral image data processing; it is also planned to include information from NWP models in this method in the future. After verification and validation, the results of this method are intended to be used as input parameters in the numerical analysis cycle for an improvement of the humidity analyses as well as for synoptical weather monitoring purposes (Rosenow, Güldner)

2.4 Precipitation Estimates

Tests have been continued of a method to estimate precipitation from METEOSAT and NOAA-AVHRR data by bispectral image processing (IR, VIS). Cloud classification is performed by pixel multiplication. Studies on the impact of different normalization methods of the VIS images for correction of different sun incidence angles have been performed and a new method has been implemented. A verification of the precipitation estimates is performed by synoptical case-by-case studies as well as statistically. The results prove to be good and reliable in many situations; the images displaying the precipitation probability are available regularly to the forecasts at the meteorological office in Potsdam. (Neumeister, Schubert, Schindowski)

2.5 Monthly Runoff Computation (Via Monthly Rainfall Estimation) on the Basis of Multi-Spectral and Multi-Temporal Satellite Imagery

Often the design of hydraulic structures suffers from the non-availability of hydrological data. In order to overcome such problems a mathematical hydrological model was developed which allows the estimation of monthly runoff values based on the information obtained from satellite imagery. The main part of this research project is dedicated to the estimation of monthly rainfall data by the utilization of remote sensing data. For calibration purposes a short period of time (e.g. one year) is required, for which ground truth has to be available as well as satellite data. Once the model is calibrated it is possible to reconstruct historical monthly rainfall values with the aid of satellite data alone.

Geostationary satellite data (B2-type, every sixth pixel in line and every sixth line) of METEOSAT are used, with a time resolution of three hours.

Three special bands have been used (visible, IR, water vapour) and it was found that the most important spectral information is the threshold black body cloud top temperature (-20 °C) while the contribution of the visible information is negligible. The water vapour channel is used in order to identify the environmental mean relative humidity around convective cloud cells. It was found that convective cloud cells with an environment mean relative humidity in the upper troposphere of less than 30 % produce negligible rainfall as well as mean relative humidities in the upper troposphere of more than 80 % due to contamination of the WV channel with non-precipitating cirrus clouds. In the intervall between 30 and 80 %, however, the information of the water vapour channel is relevant for rainfall estimation. (I. Papadakis & G. A. Schultz)

2.6 Parametrization of Hydrological Processes with the Aid of Remotely Sensed Data and Geographic Information Systems Techniques

In the framework of the Mosel Project "Development of a Distributed Hydrological Model for Flood Forecasting and Impact Assessment of Land Use Change and Climate Change in the International Moselle River Basin" financed by the Federal Ministry of the Environment, Nature Conservation and Nuclear Safety/ Federal Environmental Agency, Germany, remote sensing techniques and raster geographic information system functions are applied to generate the input data for physically based hydrological modelling which demands spatially distributed characteristics and parameters of the catchment. These data are effectively provided by integrating remote sensing products into GIS. The methodology consists of the utilization of an "Overlays" concept in which the required information, e. g. landuse, soil type, vegetation and leaf water content indices, elevation, slope, aspect, drainage network, etc., are stored and which are used for generating the so called Hydrologically Similar Units (HSUs) by means of overlaying and reclassifying. These HUSs form the spatial basis for the distributed hydrological model designed for short-term flood forecasting and the long-term simulation of the hydrological effects on land use and climate changes in the Moselle river catchment. (Z. Su, B. Hamme & G. A. Schultz)

2.7 Determination of Land Use for Water Balance Models

For the application of water balance models, land use classification is derived from LANDSAT - TM data. Parameters are interception, evapotranspiration and infiltration. The spatial resolution is variable from 30 x 30 m over 1 x 1 km to 0.5 ° x 0.5 °. The models are applied to large and small river basins as well as to political regions. (Mendel)

2.8 Satellite Data for Use in Agrometeorological Evaporation Models

First studies have been initiated to include remote sensing data in agrometeorological evaporation models. NOAA-AVHRR data in full resolution are used for the determination of horizontal land-surface-temperature gradients and a rough estimate of the soil moisture and diurnal temperature variation. In addition the AVHRR data can be used for an assessment of cloudiness and solar irradiance and a classification of vegetation types. Most of the input-parameters to the evaporation model are taken from ground-based measurement whereas it is planned to use the satellite data mainly for extrapolations from single sites to areas. First tests led to encouraging results, but studies have to be continued. (Löpmeier, Beblick).

2.9 Global Precipitation Climatology Centre

The Global Precipitation Climatology Project (GPCP) is an element of the World Climate Research Programme (WCRP) established by WMO and ICSU. The Deutscher Wetterdienst is participating in the GPCP of the WCRP by providing the Global Precipitation Climatology Centre (GPCC). The task of the GPCC is to collect, check and correct the CLIMAT and SYNOP reports disseminated via the Global Telecommunication System (GTS), to acquire additional precipitation data, and to calculate monthly areal precipitation totals on a 2.5 ° grid over land based on gauge measured data. These station based analyses have to be merged with satellite estimates and numerical weather forecast model results to describe global precipitation fully. As there are large areas on the earth with not enough gauge measurements to perform an adequate analysis, precipitation estimates based on infrared images from the geostationary satellites and microwave data from one polar orbiting satellite are used for an assessment of the precipitation over sea and to fill data gaps over land. The IR-based estimates are produced by the Climate Analysis Centre (CAC, NOAA) using the GPI method (= GOES Precipitation Index). The gaps in geostationary coverage (for example due to the lack of INSAT data) are filled by estimates based on outgoing longwave radiation (OLR) from the NOAA polar orbiting satellites. The microwave data observed by the SSM/I (Special Sensor Microwave Imager) onboard the polar orbiting DMSP satellite are compiled at the NASA Goddard Space Flight Center. From SSM/I data, monthly precipitation totals are estimated for 5 ° cells for the zone 50 ° S - 50 ° N for oceanic regions based on a histogram correlation method using the differences of the brightness temperatures from the 19 GHz and the 22 GHz channels; these estimates are sent to the GPCC. Since no satellite estimates are available for the higher latitudes, results from NWP models have to be used for completion.

Some first results on comparisons of monthly precipitation totals by gauge-based on objective analysis and geostationary satellite estimates follow. The zonal averages for mean monthly precipitation amounts for August 1987 indicate that in general satellite estimates give amounts nearly twice as large as the gauge measurements. A key question is, which estimate is nearer the truth? Due to the well- known deficiencies of the GPI method, the gauge-based data may be more reliable. On the other hand, over part of the land areas, the gauge-based data is fairly poor and ground observations are unrepresentative. Over oceanic regions the gauge-based data is completely insufficient and satellite estimates may be more accurate. (Rudolf)

2.10 Water Vapour Images for the Synoptical Diagnosis

A systematic study has been initiated on assessing the benefit of images from the METEOSAT water vapour channel for the synoptic diagnoses of the state of the atmosphere and for nowcasting and very short-range forecasting purposes. The WV images are evaluated in this study in combination with diagnostic parameters as e. g. the Q-vector or the isentropic potential vorticity which are derived from NWP output. The study is being performed in cooperation with the Karlsruhe University. (Kurz, Schimmelpfennig)

2.11 Positioning/ Monitoring of Coastal Gauges Through NAVSTAR GPS

The result of the GPS measurements for the positioning of the Helgoland gauge (other receiver locations: Wilhelmshaven, Bremerhaven, Cuxhaven) were ellipsoidal differences in elevation with accuracies of about 6 cm. 1-frequency receivers are used for this purpose. Ellipsoidal elevations are not related with the zero point reference system of the Federal German Survey.

In 1987, a major measuring campaign (4 GPS receivers in alternation) with 22 gauge locations and another 11 supplementary points of the GPS network was carried out along the German North Sea and Baltic Sea coasts up to Lübeck-Travemünde. The resultant differences in elevation were < 3 cm and out of this even 51 % were < 1.5 cm (1-frequency receiver), see Fig. 1 PEGELMAC 1987.

In 1989, a hydrostatic levelling was carried out in the Jade-Weser area (North Sea) with the assistance of the Meetkundige Dienst of the Dutch Rijkswaterstaat. At the same time GPS measurements were performed to obtain parallel to the zero point elevations the ellipsoidal elevations from satellite-based measurements. The GPS measurements produced accuracies of the ellipsoidal differences in an elevation of 1.8 cm in addition to the mm elevations in the zero point system. That result represents a substantial increase in accuracy as compared to the measuring campaign of 1987 (2-frequency receivers).

In autumn 1990, the GPS campaign of 1987 was approximately repeated with 2-frequency receivers. For staff reasons, the evaluation was delayed so that results cannot be presented.

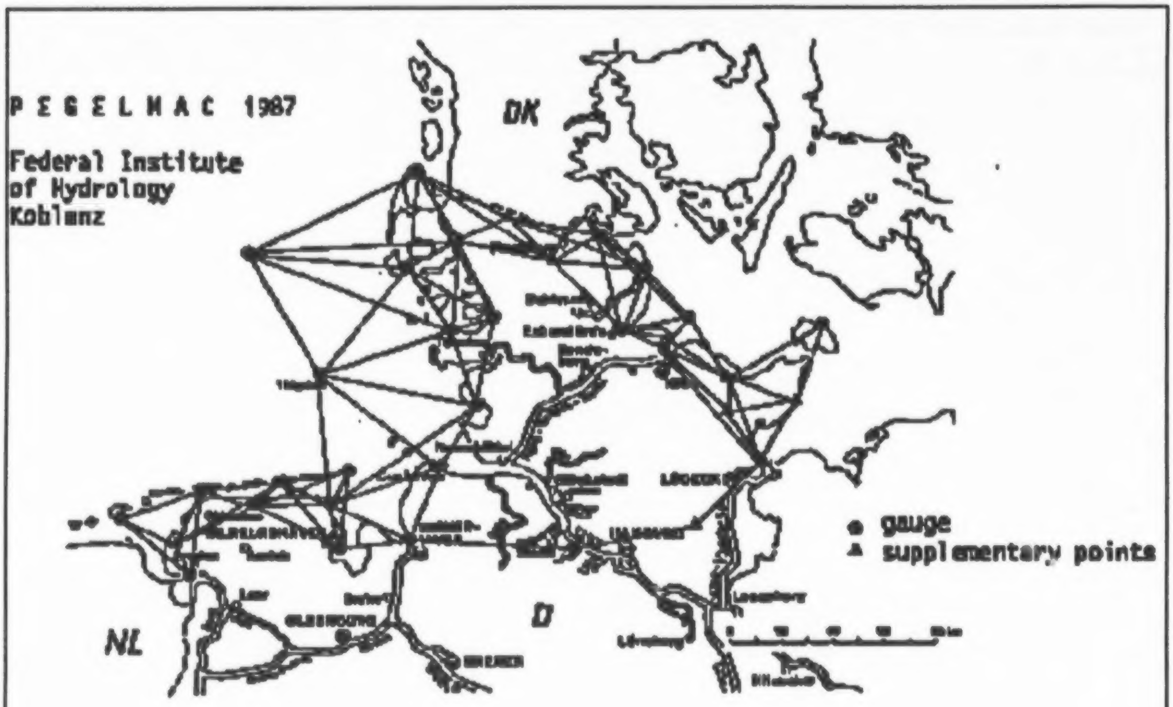

Fig. 1: PEGELMAC 1987: GPS receiver locations

Following the German reunification, for future GPS measuring campaigns including the eastern Baltic Sea

- on the one hand, the existing differences in the elevation reference systems in the old Federal states (gauges: Amsterdam, zero point system) and in the new Federal states (gauges: Kronstadt, normal elevation system) are to be taken into consideration, and
- on the other hand, the measuring procedure and in particular the evaluation of measuring data (programme system) from satellite-based measurements for use by the Water and Navigation Authorities should be optimized. (J. Behrens)

PART III APPLICATION TECHNIQUES

Some of the application techniques presently under development or already in quasi-operational use have already been described in part II, e. g. 2.4 precipitation estimates. Some indication on operational applications follow:

3.1 Use of Satellite Data in NWP

Temperature and humidity profiles, retrieved from TOVS data at NOAA - NESDIS and distributed on the GTS in SATEM code in 500 km horizontal resolution are used fully operationally as thickness data in the numerical analyses (optimum interpolation) from the whole globe without any restriction.

Software for decoding NOAA - NESDIS TOVS data in 120 km horizontal resolution in BUFR code is under development; a software module for the selection of qualitatively high valuable data has still to be developed.

Cloud motion wind vectors and sea-surface-temperatures, running on the GTS in SATOB code are used fully operationally from METEOSAT, a combination of UTH (upper tropospheric humidity) and CA (Cloud Analysis) is also used.

3.2 Interactive Satellite Image Processing

All digital satellite image data (METEOSAT, NOAA) which are received and processed at the Central Office in Offenbach are available in the workstations of the so-called Interactive Graphical System (IGS). The images can be superimposed with precipitation data from the national and European ground-based radar network, with conventional synoptical data and with graphical output fields from the different NWP models and derived diagnostic parameters. The combination of all this information results in better and more objective diagnoses of the state of the atmosphere and very short-range forecasts and permit an assessment of the correctness of numerical analyses and forecasts. Very first steps in the development of objective nowcasting methods have been taken. (Knottenberg)

3.3 Global Radiation at Ground Level from METEOSAT data

The global solar irradiance at ground level is still derived from METEOSAT data as in previous years. Daily sums and monthly means of global radiation are archived.

3.4 Cross-Calibration of METEOSAT and METEOSAT-ADC Data

As METEOSAT-ADC data (ADC = Atlantic Data Coverage) are disseminated to European users via METEOSAT without exact calibration, a cross-calibration technique has been developed and is applied. The IR pixel values in the overlap-area of METEOSAT and METEOSAT-ADC are used to fit the pixels in the ADC images to those of the calibrated METEOSAT image data resulting in equal temperature information from both satellites. (Knottenberg)

PART IV OPERATIONAL SYSTEMS FOR SATELLITE APPLICATIONS

4.1 Central Image Processing System at Offenbach

This system consists of a PDUS for reception and preprocessing of digital METEOSAT data and an HRPT station for the NOAA-AVHRR and TOVS data. The TOVS data are inverted to temperature profiles on the mainframes of the meteorological computer centre. Display and interactive processing of satellite images is performed in the Interactive Graphical System (IGS). A short description on this system was given in the previous report. The number of IGS workstations increased to a total of 10. For more details see publications (PART VII).

A pilot project has been started very successfully: digital satellite data which are received and processed with the central facilities in Offenbach are transmitted to a workstation at the Marine Meteorological Centre in Hamburg on a 64 Kbit digital public data link. There, the same satellite data applications are possible as at the Central Office in Offenbach. It is intended to provide all 7 regional meteorological centres of the DWD with digital satellite data by means of this system.

4.2 Image Processing at Potsdam

The operation of DIGISAT, consisting of a METEOSAT-PDUS and a NOAA-HRPT station, has been continued as in the previous years. A short description of this system was given in the previous report or can be found in the publications.

4.3 Local Image Reception and Processing

At the end 1991, all the regional offices and meteorological offices at airports operated by the DWD were equipped with their own SDUS for direct reception of analogue METEOSAT images. The total number of SDUS at the DWD is 27.

4.4 Data Collecting Platforms

At the end of 1991, 57 DCP's were in operation or were planned to be taken into operation very soon. The additional DCP's in comparison to earlier years have been ordered by the Federal Environmental Agency for pollution monitoring in the eastern parts of Germany. It is planned to increase considerably the number of DCP's for environmental monitoring in the future.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS

Additional regional meteorological offices operated by the DWD will be equipped with workstations which will be provided with meteorological data by means of digital public high-speed data links. The data to be transmitted are satellite data which are received and preprocessed at the central facilities in Offenbach, composites from the radar network, conventional observation data and output from NWP models in graphic files. Besides other applications these systems will be used for operational regional weather monitoring and very short-range forecasting, making use of interactive processing techniques.

PART VI VERIFICATION OF OPERATIONAL PRODUCTS

The following table gives the results of a comparison between TOVS data, retrieved at NOAA - NESDIS, distributed on the GTS in SATEM code in 500 km horizontal resolution and radiosonde measurements over Europe. Allowed time difference between satellite and radiosonde measurements is about 1.0 to 2.5 hours, maximum horizontal distance is less than 1 degree. The statistic is calculated from thickness data from the year 1991 with measurements around 12 UTC.

Thickness (GPM)

layer	850/x	700/x	500/x	400/x	300/x	250/x	200/x
RMS	20.6	36.3	54.0	68.9	92.1	101.6	104.9
bias	4.1	7.9	12.0	15.8	22.3	25.3	28.8
no. of comparisons	683	679	679	679	678	679	678

layer	150/x	100/x	70/x	50/x	30/x	20/x	10/x
RMS	104.2	96.4	93.1	97.7	113.3	161.3	294.1
bias	29.7	19.3	11.3	4.9	- 2.0	- 33.5	-110.2
no. of comparisons	678	678	676	677	680	675	677

Statistics on comparisons TOVS - SATEMs versus RADIOSONDE measurements
x = level 1000 hPa RMS = root mean square error

PART VII OTHER ITEMS

References, Publications

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HONG KONG

Royal Observatory Hong Kong

PART I A BRIEF SUMMARY OF THE MAJOR HIGHLIGHTS OF RESEARCH APPLICATION AND OPERATIONAL CHANGES

1.1 There were no major operational changes in 1991.

1.2 The ground reception system functioned satisfactorily, with cloud images in digital format (Stretched-VISSR) being received hourly from the Japanese Geostationary Meteorological Satellite (GMS).

1.3 The hourly GMS pictures greatly facilitated the monitoring of tropical cyclones and rainstorms in our area.

1.4 For back-up purpose, WEFAX (Weather Facsimile) from GMS and APT (Automatic Picture Transmission) from NOAA satellites were also received.

1.5 SATEM reports (satellite remote upper-air soundings) and SATOB reports (satellite meteorological observations) were received through the Global Telecommunication System (GTS) and used in routine upper-air analysis and in tropical cyclone analysis.

1.6 SAREP reports (synoptic interpretation of cloud data from a meteorological satellite) on tropical cyclones issued by the Japanese Meteorological Agency (JMA) were also received and used in tropical cyclone analysis and forecasting.

PART II A DESCRIPTION OF THE MAJOR RESEARCH AND DEVELOPMENT IN THE APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

2. A joint project is being carried out between the Royal Observatory and a local academic institution to develop a prototype system for the objective analysis of satellite data based on the neural network concept.

PART III A DESCRIPTION OF TECHNIQUES DEVELOPMENT AND APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

3. A computer work-station for off-line satellite data processing and display is being developed in collaboration with a university in Hong Kong. The system is designed to store up to 16 satellite images and to display the animated sequence on a video terminal. Infra-red imageries are enhanced to highlight sea surface temperature features, sea fog and the development of tropical cyclones.

PART IV A BRIEF DESCRIPTION OF THE SYSTEM FOR SATELLITE APPLICATIONS IN CURRENT OPERATIONAL USE

4.1 GMS ground reception system

4.1.1 A block diagram of the GMS ground reception system is shown in Figure 1.

4.1.2 The equipment consists of a 5-metre diameter antenna, a signal receiver, an image processor and an image analyzer at the Royal Observatory Headquarters, and a remote display at the Airport Meteorological Office in the Hong Kong International Airport.

4.1.3 The image processor utilises a dedicated microprocessor for processing and distribution of data from the signal receiver. All processing functions are carried out automatically according to a pre-defined schedule.

4.1.4 The received image is displayed on a video monitor and at the same time stored on a hard disk. The image is then sectorized according to a pre-defined geographical area for animation display on the image analyzer. It is also sent to the remote display at the Airport via a PC-to-PC (personal computer) link.

4.1.5 Black-and-white hard copies of satellite image are produced using a laserfax recorder.

4.1.6 At regular intervals the received satellite data is transferred from the hard disk to a magnetic tape for archival.

4.1.7 WEFAX pictures received are displayed on a video monitor after processing by a PC-based image processor. Hard copies are reproduced on a facsimile recorder.

4.2 APT ground reception system

4.2.1 A block diagram of the APT ground reception system for NOAA satellite images is shown in Figure 2.

4.2.2 The VHF transmission from the NOAA polar orbiting satellite is received via an omni-directional two-turn helical antenna.

4.2.3 The radio signal is amplified and fed into a receiver which demodulates and outputs the sub-carrier to a decoder, a facsimile recorder and a audio cassette tape recorder.

4.2.4 The decoder digitises the analogue signal for storage and for display on a video monitor.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEM FOR SATELLITE APPLICATIONS TO METEOROLOGY AND OPERATIONAL HYDROLOGY

5.1 The feasibility of incorporating satellite data as input to in-house Limited Area Models will be examined.

5.2 The development of display facilities to integrate satellite data with other meteorological data for the purpose of short-range forecasting will be pursued.

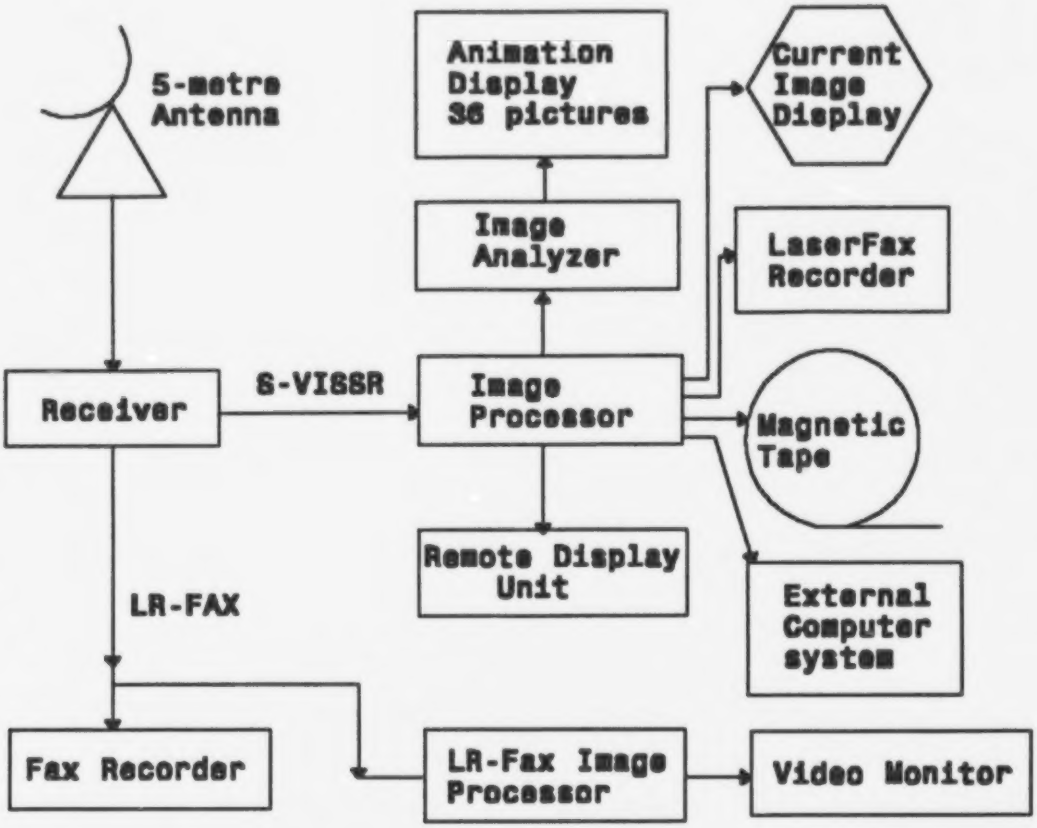

Figure 1. - Block diagram of the GMS reception system

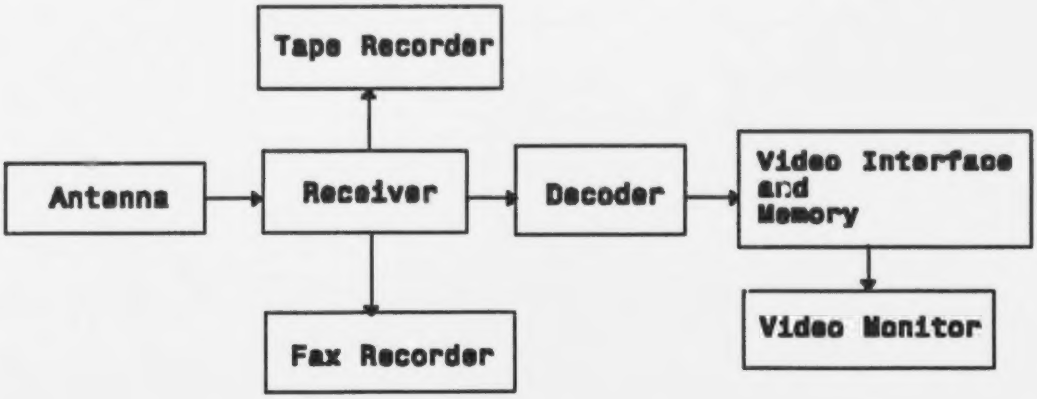

Figure 2. - Block diagram of the NOAA APT reception system

HUNGARY

PART I Summary of the major highlights of research applications and operational changes

1. Two digital receivers began experimental operation, one for the METEOSAT and one for the NOAA satellites. Most of the previously operated SDUS stations remained in operation. The research and application work follows the hardware changes. Parallel with the experimental installation of the NOAA HPPT receiver and the METEOSAT PDUS the experimental application of the information provided by them to the forecasting practice has been started. The development activity backing the further application has been hastened.

PART II Major research and development in the applications of satellite data,derived products and services

2. The basic direction of research was the investigation of the surface: components of the radiation budget, evapotranspiration, vegetation index, etc. Programs have been developed or modified to produce maps of radiative temperature, cloud parameters, temperature, humidity and ozone from TOVS data. Cold front structure and precipitation variations in thunderstorms have also been investigated.

PART III A description of techniques development in the applications of satellite data,derived products and services

3. The forecasters use routinely both the METEOSAT WEFAX cloud pictures and the HRPT pictures in their analysing work. The digital METEOSAT pictures get into the computer network serving the forecasting activity. Out of the information contained in the images the cloud top temperature fields can be (experimentally) represented in polar-stereographic projection in several scales.

PART IV System for satellite applications in current operational use

4. SDUS stations have been used for several years by different divisions of the Hungarian Meteorological Service. The two digital receivers are connected to a PC-LAN that serves the central forecasters' activity.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. The experimental operation of the digital systems will gradually change into operational service for synoptic and numerical weather analysis. An archive of the digital information is planned for the next 8 to 10 year data series to facilitate any application or research work. The archiving onto magnetic tapes will be changed using compact disks. In order to analyze the precipitation field as exactly as possible, a computer system for the joint interpretation of digital METEOSAT and radar images is being developed.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. Airplane measurements of the surface temperature, surface (point) measurements of the evapotranspiration are made. The fields derived from TOVS data will be checked.

PART VII Other items (references, publications and names of scientists in charge, etc.)

Sounding: Mr. I. CSISZAR

Surface radiation budget: Dr. A. RIMOCZI-PAAL (MRS)

Cloud classification, cold front investigations: Ms E. FEJES

Surface temperature, precipitation: Ms J. KERENYI

Vegetation: Mr. V. VADASZ and Dr. Z. DUNKEL

Analysis of precipitation field: Ms A. TAKACS

Development activity relating to operational application: Mr. V. VADASZ

INDIA

PART I Summary of the major highlights of research applications and operational changes

1. A new system for reception and processing of data from INSAT-I and INSAT-II series of satellites is being installed.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 Estimation of relative humidity profiles

Fractional cloudiness data available from INSAT has been classified into different cloud categories depending upon the total cloud amount and the levels at which the clouds have been present. Keeping this information in view, most frequently occurring humidity profiles have been built using Minicoy and Port Blair temperature data. The preliminary results indicate that these bogus relative humidity profiles could provide useful information on moisture distribution in the vertical over the Indian Ocean.

2.2 Use of satellite based information in snow-melt run-off studies

A study aimed at evolving a technique for computation of water yield in a snow-bound river basin have provided realistic estimates of snow-melt induced water yield. Very high resolution imagery received from NOAA-9 has been used for this purpose. The study has shown that satellite derived snow cover data are potentially useful in predicting the snow-melt run-off, especially for the large water sheds over the Himalayas where ground based measurements are too scanty.

2.3 Some aspects of the Southwest Monsoon

A study of the satellite cloud imagery for the years 1978-79 & 1984-88 has indicated that the cross equatorial flow, its location and intensity, play an important role in the onset of the southwest monsoon and its activity during the season. The southern hemispheric equatorial trough (SHET) plays the role of regulating the cross-equatorial flow thereby leading to development of different phases of the southwest monsoon. The inverse relationship between the intensity of the SHET and the monsoon activity can be used as a tool in the forecasting of dry and wet spells.

2.4 A basic guide for INSAT imagery

It is a meteorological monograph containing basic principles of satellites cloud image interpretation, seasonal and diurnal effects as reflected in the images, gray scale enhancements, primary synoptic systems, various features of monsoon circulation, tropical cyclones, cloud systems of importance to aviation and miscellaneous surface features as viewed in the images and their significance. This was prepared for the guidance of forecasters all over the country who use INSAT imagery in their daily analysis.

2.5 Activity of southern Indian Ocean convergence zone as seen in satellite cloud data during pre-monsoon months

The weekly mean cloud cover data for the pre-monsoon months of April and May over the Indian Ocean between 20N to 20S latitudes and 40E to 100E longitudes have been studied both for good and bad monsoon years. It is seen that a cloud band across the equator or a well developed east-west band north of the equator in the pre-monsoon appears to be the signal for a good monsoon in that year. An active Southern Indian Ocean Convergence Zone (SIOCZ) is an indicator of forthcoming bad monsoon. Continuous monitoring of SIOCZ activity in the pre-monsoon could be helpful in determining the seasonal performances of the southwest monsoon.

PART III A description of technical development and application of satellite data, derived products and services

3.1 Meteorological Data Utilization Centre (MDUC) at New Delhi continued to receive and process data from INSAT-1D satellite during 1991. Satellite imagery was used to monitor tropical cyclones that developed in the Bay of Bengal, and precipitating convective systems particularly during the monsoon. The following quantitative products continued to be available in 1991

(a) Cloud motion vectors at 06 UTC

(b) Quantitative precipitation estimates

(c) Outgoing longwave radiation

(d) Sea surface temperatures

PART IV System for satellite applications to meteorology and operational hydrology

4.1 The India Meteorological Department is utilizing the INSAT-I satellite system for providing meteorological support to the operational weather forecast. Earth cloud cover data are provided by utilizing very high resolution radiometer (VHRR) operating in the visible and infra-red channels at a resolution of 2.75 km in the visible and 11.0 km in the infrared. The system is designed to provide half hourly data for full earth disc along with sector scans for limited areas once every six minutes.

4.2 One hundred receivers of the Disaster Warning System (DWS) are operational since January 1986 in the two southern coastal states of India for direct reception of warning about the natural disasters due to cyclones. These stations continued to provide useful service in 1991. These cyclone warnings received through DWS were helpful to the State/Government for taking timely action against the impending disaster. 50 more DWC receivers are being installed shortly in the coastal areas of West Bengal, Orissa, north Andhra Pradesh and Gujarat. Equipments have been received and installation plans are being prepared.

4.3 INSAT-ID imagery is now available in near real time basis at 20 Secondary Data Utilization Centres (SDUCs) located in the various forecasting offices of the country. A new scheme of Meteorological Data Dissemination (MDD) is being operationalized in which it would be possible to receive FAX charts, satellite imagery and meteorological data in the Indian area. A total of 23 stations are being established in this connection.

PART V Plans for future operational systems of satellite applications to meteorology and operational hydrology

5.1 The existing INSAT-I series of satellites will be replaced in the 1990s by the indigenously made second generation of INSAT satellites (INSAT-II). The first satellite of INSAT-II series viz. INSAT-2A was launched using Ariane launch vehicle on 10 July 1992. The basic design of INSAT-II satellite is similar to the existing satellite of INSAT-I series although there would be some improvements.

5.2 The Very High Resolution Radiometer (VHRR) on-board INSAT-II will have improved capabilities compared to the VHRR on the existing INSAT-I series of satellites. The major improvements will be in terms of resolution in the visible and IR channels and three modes of operations. The INSAT-II VHRR will have a resolution of 2.0 km in the visible and 8 km in IR against 2.75 and 11 km in INSAT-I series.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

Nil

PART VII Other items (references, publications and the names of scientists in charge, etc.)

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3. Mishra D.K., Gupta G.R., Onkari Prasad and Tribhuwan Nath, 1991 Some aspects of southwest monsoon, as seen in satellite cloud imagery, Mausam, 42, 3, 261-64.

4. Kelkar R.R., and Yadav B.R., 1991 A Basic Guide for the Use of INSAT Imagery, Division of Satellite Meteorology, India Meteorological Department, New Delhi, July 1991.

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IRAN

With the guidance of WMO, through UNDP, during 1991 a search was conducted to obtain a suitable satellite receiving system for Islamic Republic of Iran Meteorological Organization (IRIMO). From the five companies making the offer, a German company UKW Technik was selected. PC/SAT weather satellite receiving equipment was installed on 22 February 1992. Installation took one week and local operating training class took another week which started on 29 February 1992. Weather satellite receiving system PC/SAT is for Meteosat SDUS and PDUS and NOAA APT.

Summary of the equipment and system configuration is as follows:

(a) Meteosat front-end
3.0m diameter parabolic antenna
PDUS SHF-preamplifier
multiple PDUS/SDUS unit with integrated amplifier
PDUS converter/receiver with demodulator
SDUS/NOAA converter/receiver with demodulator
cable and connectors (40m)

(b) Preprocessor unit for PDUS/SDUS/NOAA
PDUS bit/frame synchronizer
PDUS preprocessor for real time data acquisition with 2MB
Buffer RAM and parallel data transfer
SDUS/NOAA preprocessor

(c) PDUS host computer and PDUS/SDUS image processor
PDUS 80386 processor with 16 MB RAM, 80 MB harddisk
Floppy 5 1/4", streamer 120 MB, VGA graphic board, mouse, keyboard,
serial/parallel interface, PDUS-parallel interface

Terminal monitor 14"
Color monitor Super VGA 20"
Operating system DOS 4.0

(d) Software for reception and graphic for satellite images
PDUS satellite reception, data acquisition and image graphic software

SDUS satellite reception, data acquisition and image graphic software

(e) Video copy-processor (148 X 200)

(f) Extension for simultaneous NOAA reception (APT)

Modular software, written in C and Assembler 386, lends the system a high performance with simplest menu-controlled operation. The pictures are able to be enlarged by a factor of 10X. A histogram is computed for any chosen inspection area. There is a selection of up to 50 colour-tables available for the various spectral ranges. Super resolution and colours (a range of 256K) using VGA mode. A time-lapse movie consisting of up to 60 pictures can be produced. The movie can be played forwards or backwards. The user is able to configure up to four separate movies. The IR and WV data are calibrated for temperature analyses. On the whole, the system is PC based and versatile.

The progress since February 1992 includes:

- The operation training classes for forecasters by local experts.

- Time lapse movies are used to note diurnal heating of land and sea surfaces; direction and amount of cloud and dust movements; development of weather systems and general circulation.

- The system is used half hourly to aid forecasters.

There have been problems with the PDUS and SDUS systems on several occasions. The problems have been solved locally, but it has taken time. Since the system is new, it is expected. Most of the time is taken to train local forecasters that use the system and there has been no major research applications to report.

This report has been prepared by Miss Megrnaz Bijanzadeh Satellite Expert at IRIMO.

IRELAND

Irish Meteorological Service

PART I Summary of major highlights of research applications and operational changes

1. No major operational changes or research applications.

PART II Major research and development and applications of satellite data, derived products and services

2. No major research or development in this area.

PART III Description of technique development and applications of satellite data, derived products and services

3. Application of derived products: SATEM AND SATOBs (Cloud Motion Winds) used in Automatic Data Extraction and Analysis for NWP.

PART IV System for satellite applications in operational use in 1991

4. SDUS with two stores and displays and APT for general forecasters' use in the Central Analysis and Forecast Office. SDUSs at two airports for aviation forecast use.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. PDUS under active consideration.

PART VI Validation and verification of satellite data and derived products used in operations

6. No verification / performance statistics available.

PART VII Other items (references, publications and names of scientists in charge, etc.)

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ITALY

Italian Meteorological Service

PART I SUMMARY OF HIGHLIGHTS

1.1 Operational facilities

During 1991, a major refurbishment of the system for METEOSAT and NOAA reception and processing, installed at the National Meteorological Centre (NMC) of the Italian Meteorological Service, Rome, has been completed. The refurbishment included the addition of two microVAX computers for off-line processing and the installation of five integrated SDUS/DCP/MDD stations.

The DCP network (10 stations operational) performed as nominal. Further 50 DCPs, to be deployed during 1992-1993 have been commissioned. The evaluation of a prototype station is in progress.

According EUMETSAT programmes, an MDD uplink station was installed at NMC and it has been operational since April, 1990. Five MDD user stations, part of the Integrated SDUS stations have been installed.

Since May 1991, the Italian Meteorological Service is acting as a node for ERS-1 FD data distribution. ERS-1 data received from ESA/ESRIN are routinely transmitted to Bracknell and the ECMWF.

1.2 Applications

The international TOVS Processing Package, version 4 (ITPP-3) has been successfully installed on an microVAX 3800 computer and profiles are retrieved operationally. The implementation of the 3I software package, acquired by the LMD, is in progress on an IBM 3090/120 mainframe.

The potentiality of meteorological satellites for forest fires detection has been investigated.

PART II RESEARCH AND DEVELOPMENT APPLICATIONS

2.1 TOVS processing

The operational software package ITPP-3 for soundings retrievals has been replaced by the new release ITPP-4, installed on a microVAX 3800 computer. The implementation of the 3I software package is in progress.

In addition to temperature and humidity profiles, total ozone content from IR radiances is also retrieved by means of ITPP. Satellite derived total ozone fields have been compared to meteorological maps for the upper troposphere, showing a potentiality for ozone maps to be used operationally for nowcasting and NWP models.

2.2 Forest fires detection

The potentiality of meteorological satellites for forest fires detection has been investigated, and in particular the use of channel 3 of AVHRR, due to its high sensibility to hot spots, allowing detection of fires with dimension lower than the nominal resolution.

An applications has been carried out to monitor a fire detection from satellite over Sardinia and a possible operational use has been suggested.

PART III TECHNIQUES DEVELOPMENT

3.1 Systems

3.1.1 Satellite data reception

During 1991, a major refurbishment of the PDUS and HRPT systems for METEOSAT and NOAA reception and processing (called ANDROMEDA system), installed at the National Meteorological Centre of the Italian Meteorological Service has been completed. The refurbishment included a complete revision of the antenna systems and the addition of two systems for off-line processing.

As far as the digital reception chains are concerned, the two front end computers, for Meteosat and NOAA reception, have been backed by two microVAX 3800 computers, all systems connected together via ETHERNET link. One of the two systems is devoted to research and development applications of satellite data and it is connected to a graphic work station VDS, 64 Mbytes RAM; the other is devoted to non real-time operational production, distribution of products to remote users and archiving operations. The two front ends are left for data acquisition, preprocessing and presentation of real-time products (such as Cloud Top Height and animation of sequences).

Furthermore, the ANDROMEDA system has been also connected via ETHERNET link to the main computer Centre of the NMC allowing a fast access to other meteorological data needed for satellite derived products.

An outline of the ANDROMEDA system is shown in fig.1

On the SDUS side a new Integrated SDUS/DCP/MDD station (ISDUS) has been developed in house, with the capability of receiving simultaneously WEFAX, DCP and MDD data.

The station is based on a network of PCs and it is equipped with a graphic controller, 14 Mbytes RAM, 135 Mbytes mass storage, capable of animating up to 54 images, 512x512 pixel, allowing zooming, panning, colour coding and other image handling facilities.

The MDD part of the station allows the selection of messages and maps to be received, displayed, printed or stored. It is also be possible to retrieve stored messages for printing.

A scheme of the ISDUS station is shown in fig.2

3.1.2 DCP data

50 "second generation" DCPs have been commissioned to be deployed during 1992-1993. The evaluation of a prototype station is in progress.

Major improvements for the future stations will be the addition of four more sensors (visibility, sunshine duration, electrical discharges, snow depth) and the possibility of working both in a full automatic and in a semi-automatic way, allowing the insertion of visual information in the SYNOP message.

3.1.3 MDD station

According EUMETSAT programmes the Rome uplink station has been installed at NMC and it has been operational since April 1990. The station is connected to the message switching system of Rome RTH and is transmitting routinely alphanumeric data.

Five user stations, part of the ISDUS stations (see paragraph 3.1.1) have been installed at main peripheral meteorological offices to be used as back-up for the ordinary meteorological transmissions.

3.1.4 ERS-1 data distribution

Since May 1991, the Italian Meteorological Service is acting as a node for ERS-1 FD data distribution. ERS-1 data received from ESA/ESRIN are routinely transmitted to Bracknell and the ECMWF.

3.2 Applications

The following images from processed satellite data have been produced, to be included in a monthly climatological bulletin:

a. from METEOSAT:

- monthly mean of total cloud cover, in percent, every three hours, plus daily total average;
- daily soil thermal excursion, every ten days;
- albedo, every ten days;
- Apparent Thermal Inertia, every ten days;

b. from NOAA

- Normalized Vegetation Index, every ten days;
- Sea Surface Temperature, every ten days;

All maps are produced over Italy and seas, at pixel level.

PART IV DESCRIPTION OF OPERATIONAL SYSTEM 1991

4.1 Operational facilities

The facilities utilized at the Italian Meteorological Service for exploiting satellite data are the following:

- The ANDROMEDA system, for reception and processing of digital data from METEOSAT AND NOAA, located at the NMC in Rome;
- an ISDUS, also located in Rome;
- 4 other ISDUSs, located at main peripheral meteorological offices;
- 49 other SDUSs located at any other peripheral meteorological offices;
- remote terminals (FAX) of the SDUSs, in various sites
- ten DCPs located in various sites, all over land.

4.1.1 The ANDROMEDA system

The ANDROMEDA system is inclusive of a PDUS and a HRPT station backed by the ISIDE system for research and development, archiving and product distribution.

4.1.1.1 The PDUS station

The PDUS station is inclusive of the following sub-systems:

a. receiving system, based on a 5 m parabolic antenna and devices for digital signal handling;

b. computer system, based on a PDP 11/44 CPU with 2 Mby central memory, floating point processor, three array processors for dedicated tasks, two tape units for safeguard of incoming data and archive, two disks unit (10 Mby each) for supporting the operation of the animation device, line-printer console, video terminals and a quick-look device for monitoring the incoming data;

c. mass storage (two disk units, 122 Mby each) to collect the B format images acquired in the last 32 hours plus a selection of A formats;

d. two hard-copy devices: one for operational use (dry-silver paper), the other for selected high quality prints (wet-chemical) development);

e. animation device, which is the core of the whole station. This device calls in sequence up to 32 images, 256x256 pixels (or 8 images 512x512 pixels). The sequence is repeated on a movie-loop, and automatically up-dated with the last image acquired, every half an hour. The operator has various possibility to select the position of the TV frame within the images resident on the mass storage, to select resolution, scale factors, speed of the movie-loop, to apply false colouring etc.,. The animation device is connected to two work stations, one in the operators' room, the other controlled by forecasters. The movie-loops can be recorded on a video-cassette system. A scheme of the PDUS system is shown in fig. 1

4.1.1.2 The HRPT station

The HRPT station is inclusive of the following sub-systems:

a. a receiving system, based on a parabolic steering antenna, 3.5 m diameter, and devices for tracking and digital signal handling;

b. a computer system based on a PDP 11/44 with 1.5 Mby Central Memory, floating point processor, two tape units, three disk units (10 Mby each), line printer console and video terminals;

c. a mass storage (two disk units, 122 Mby each) for storing the last 12 min NOAA pass (or more shorter passages) and over 400 images, 512x512 pixels;

d. one photo-recorder for high quality hard copies (wet-chemical development);

e. one graphic-pictorial interactive systems for image analysis based on a TESAK 501, 256 Kby RAM system.

A scheme of the HRPT system is shown in fig. 2

4.1.1.3 The ISIDE system

The ISIDE (Interactive System for Image Data Elaboration), mainly devoted to R & D applications and product distribution, is inclusive of the following sub-systems:

a. two computer systems microVAX 3800 each with 16 Mby Central Memory, floating point processor, streamer, one tape unit, line printer, console, video terminals;

b. mass storage (two disk unit, 622 Mby each);

c. two high capacity tape unit (EXABYTE) for long term archive;

d. one electrostatic plotter-printer with special software for simulating hard copies, besides the ordinary utilities of any plotter and printer;

e. one graphic work station (VDS 7001 EIDOBRAIN) with 64 MBy RAM memory, mass storage 170 MBy, floppy disk driver.

f. photographic POLAROID video hard copy;

A scheme of the ISIDE system is shown in fig. 3

4.1.2 The ISDUS stations

Five Integrated SDUS stations have been installed to replace the oldest 10-years-old SDUS stations. Each station is inclusive of the following sub-systems:

a. WEFAX receiving system, based on a 286 PC, 2 Mby RAM, 20 Mby mass storage, with the function of monitoring the reception, converting the analogue reception into digital and storing each acquired image before sending the selected ones to the archiving station.

b. archiving station, based on a 386 PC, 4 Mby RAM, 135 Mby Mass storage , with the function of programming acquisition of both WEFAX images and DCP data, managing archives, retrieving images or DCP messages to be printed or copied;

c. graphic station, based on a 286 PC, 2 Mby RAM, 20 Mby Mass storage plus 14 Mby RAM graphic controller for visualization and animation of archived sequences, automatically updated and a local archive of processed images.

d. MDD receiving station, based on a 386 PC, 2 Mby RAM, 20 Mby Mass storage, with the function of programming acquisition from both MDD channels, managing archives, retrieving maps or messages to be printed, displayed or copied.

4.1.3 The SDUS stations

Various type of SDUSs are operational at the peripheral offices of the Italian Meteorological Service, most of them with the capability of animation, false colouring, zooming and hard-copies devices.

4.1.4 Remote terminals

12 remote terminals are at present operational, connected to the Rome SDUS to receive METEOSAT images and other processed products in WEFAX format via a dedicated telephone line. All are equipped with a dry-silver photo-recorder and a TV monitor. The reconversion of functions and structure of the remote terminals is under way (see paragraph 5.1)

4.1.5 The DCP network

Ten DCP stations are operational. Their location is shown in fig. 3, together with the position of conventional stations operating at present (about one hundred). Each DCP is measuring eight parameters: atmospheric pressure, wind speed, wind direction, air temperature, air humidity, precipitation, soil temperature and global solar radiation.

4.2. Operational products

The following operational products from processed satellite data are available:

- animation of METEOSAT images;
- remapping of METEOSAT images in stereographic projection;
- Cloud Top Height from METEOSAT images, every half an hour;
- TOVS retrieved profiles.

4.3 Archiving

Satellite data are archived at NMC according to the following strategy:

a. METEOSAT data:

- 30 days archive:

  BV and BI formats every 3 hours; AI format every 3 hours;

- permanent archive:

  window over Italy in IR every 3 hours; two AI format/day;
  everything during selected periods

b. NOAA data:

- 10 days archive: AVHRR: 2 pass/day;
- permanent archive: AVHRR: selected periods and situations;
  TOVS: raw data + retrievals

All data are available on CCTs, EXABYTE and prints

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS

5.1 Systems

Short term development of the ANDROMEDA system at NMC will include:

- replacement of front-end computers of both PDUS and HRPT with more updated systems (VAX family);
- improving of the archiving facilities by means of the acquisition of DAT cassette and optical disc units.
- enhancement of graphic capacity by means of the acquisition of new DEC 5000 work stations.

On the SDUS side the capability of the new ISDUSs will be improved by means of new photographic printers and the possibility of displaying MDD received GRIB fields.

The remote terminals, described in paragraph 4.1.4, are being updated and reconverted for receiving from NMC, in WEFAX format, pseudo-images from processed satellite data (e.g.CTH maps) or high resolution subframes of NOAA images. The possibility of using digital transmission is under study.

As far as the use of DCP is concerned, the first set of 50 DCPs already commissioned will be installed by end 1992. A further set of more 60 stations will be commissioned.

5.2 Applications

The main items for development of new applications have been identified in the following areas:

5.2.1 TOVS processing

The development of TOVS processing is considered along the following lines:

- optimization of retrieval coefficient for the Mediterranean area;
- use of AVHRR data for better determination of SST and declouding;
- use of TOVS output (e.g. precipitable water) as input data in the fine mesh Limited Area Model;
- use of TOVS retrieval for a better determination of the cloud top height derived from METEOSAT images;
- use of TOVS-derived total ozone content for validation and calibration of the National Ozonometric Network;
- implementation of 3I software package for TOVS processing.

5.2.3 Precipitations and heavy convective clouds identification

A merging of satellite and radar data will be developed for the identification of heavy convective clouds and subsequent linear evolution for nowcasting will be developed. The application of algorithms for determination of rainfall intensity and amount in an operative procedure will be investigated.

PART VI OTHER ITEMS

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PAGANO P., DE LEONIBUS L., SCHIARINI S. (1991) - Use of AVHRR Data in the Air-Sea Interactions - Proc. 5th AVHRR Data Users' Meeting - Tromso - EUMETSAT Publ., Darmstadt

6.2 Contacts

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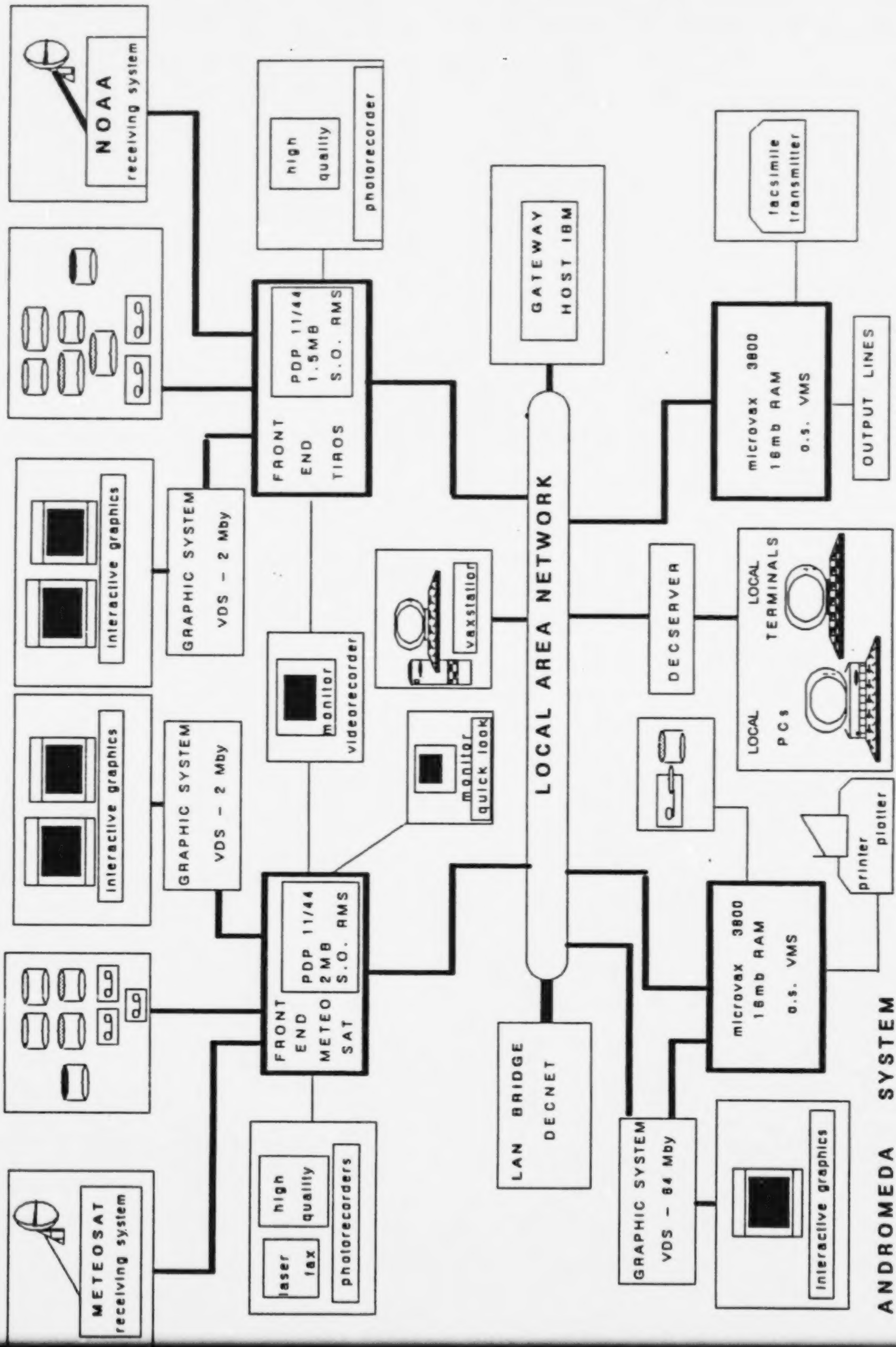


ANDROMEDA SYSTEM

Fig. 1

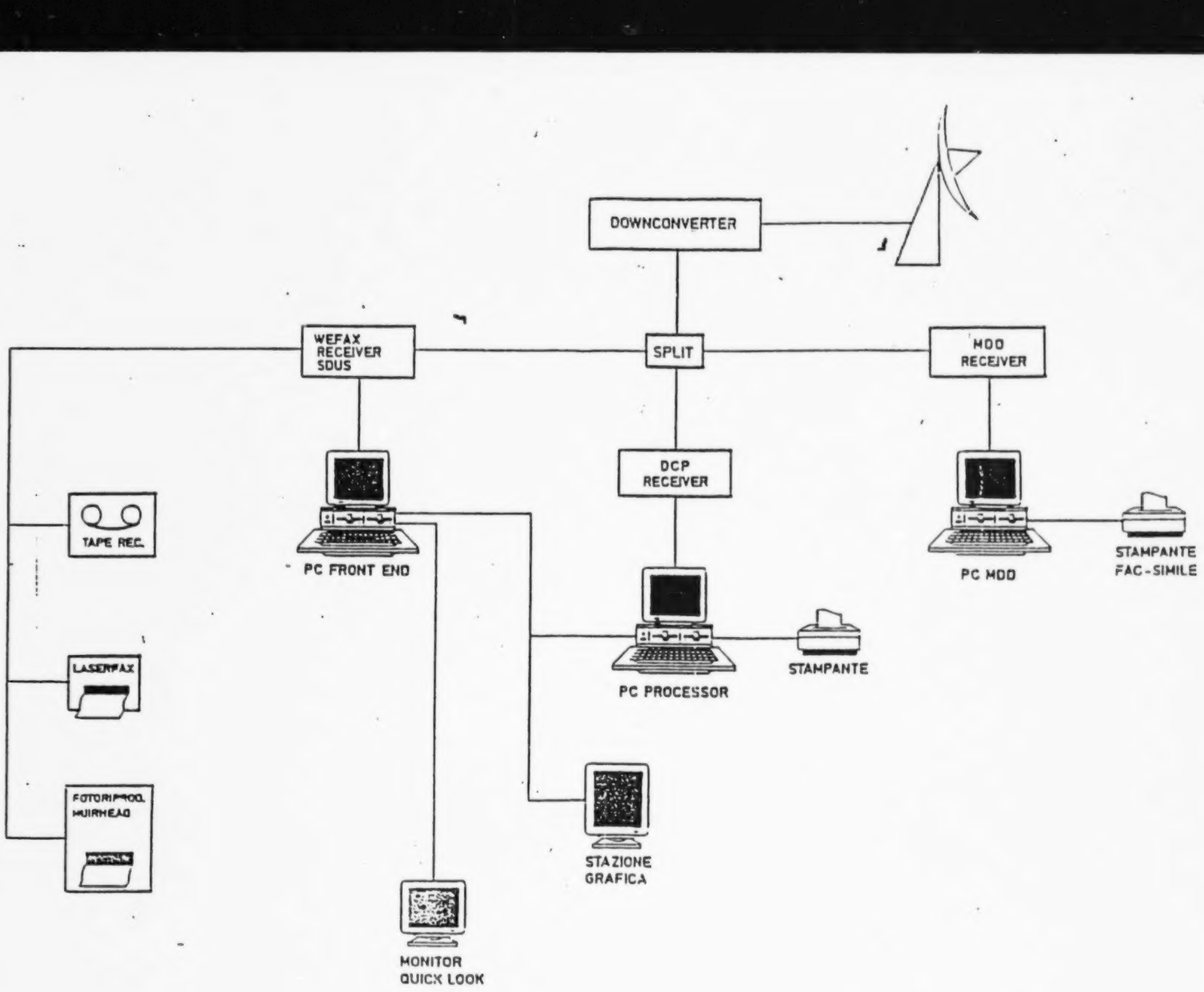
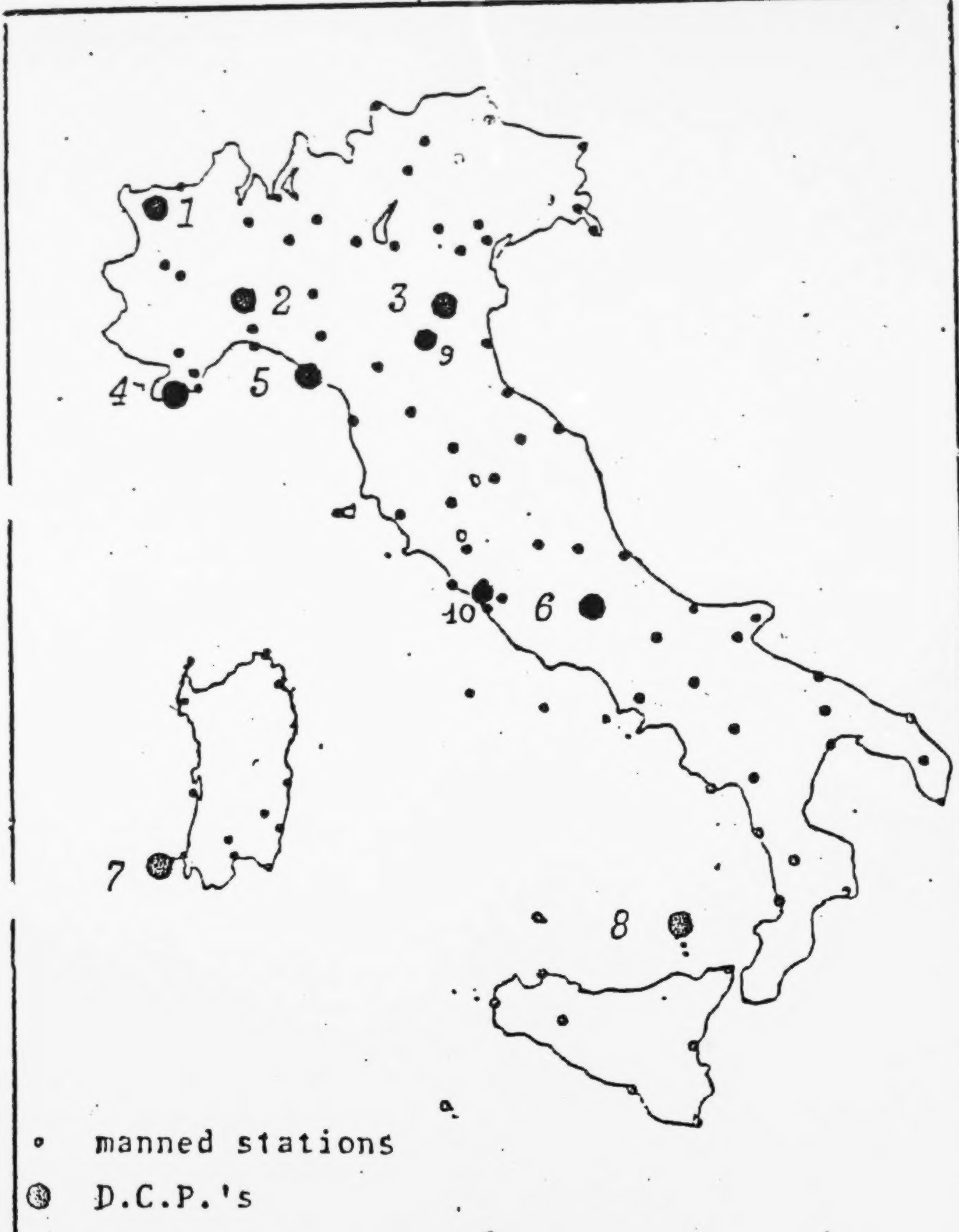


FIG. 2 — LAY-OUT SISTEM SDUS / DCP / MDD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• manned stations
● D.C.P.'s

JAPAN

Japan Meteorological Agency (JMA)

PART I Summary of the major highlights of research applications and operational changes

Improvement of Manual Quality Control Procedure of High-level Cloud Motion Winds

1.1 Representative heights are assigned to the high-level cloud motion winds using a look-up table defined statistically. The derived cloud motion winds are automatically checked and are followed by a manual check with the rawin data and the JMA's 12-hour forecast winds to eliminate unreasonable winds.

1.2 In order to complement the statistical height assignment method, the manual quality control procedure was modified in April 1991. As a result, operators can manually change the statistically assigned height in referring to the rawin winds and the forecast winds. The new operation is especially applied to winds in the vicinity of the Jet Stream in the northern hemisphere.

Utilization of High Resolution Forecast Data in Producing Satellite Cloud Information Chart

1.3 Satellite Cloud Information Chart (SCIC) is used at the local meteorological offices for operational short-range forecasts. The patterns of cloud distribution in the SCIC are automatically produced using an operational cloud analysis algorithm. Significant meteorological information is manually added to the SCIC by means of a neph-analysis with high-resolution (0.2°, 11 layers) forecast data, which are output from the JMA's regional numerical prediction model, *i.e.*, Japan Spectral Model.

Moisture Analysis using GMS Cloud Data

1.4 Using cloud data obtained by GMS, vertical moisture profiles have been estimated and are used in the operational moisture analyses at the JMA.

1.5 The GMS cloud data are compiled from equivalent black body temperatures retrieved from infrared radiation observations by GMS at the Meteorological Satellite Center (MSC/JMA). They consist of several parameters which represent the cloud characteristics in each 0.5- by 0.5-degree latitude/longitude grid box over the area 50°N-50°S, 90°E-170°W. The main parameters are cloud amount, mean cloud top height and standard deviation of the cloud top temperature.

1.6 Conversion from the GMS cloud data to moisture profiles is based on the statistical relationship between cloud types defined by the satellite cloud data and radiosonde observations. The vertical moisture profiles from co-located radiosonde observations are assembled to determine the mean profile for each cloud type, and the standard deviations are computed at standard pressure levels.

1.7 In the operational moisture analysis, cloud type is given for each 0.5-degree mesh. The mean moisture profile as obtained above is given as moisture data and its standard deviation is adopted as the observation error. Those data are blended with the first guess of moisture fields produced by the JMA forecast models in the course of OI (Optimum Interpolation) analysis.

1.8 The use of the estimated moisture data in the forecast/analysis cycle produces moisture fields which are realistic compared with cloud images obtained by GMS over tropical and subtropical ocean where conventional data are too sparse to perform accurate moisture analysis.

1.9 Moisture data are also found to contribute significantly to the improvement of NWP in the tropics. In particular, precipitation forecasts in the tropics have been improved, at least qualitatively. Tropical meteorological phenomena, such as tropical cyclones and Australian monsoon onset, which is driven by precipitation, are now better predicted.

PART II Major research and development in the applications of satellite data, derived products and services

Monitoring of the Global Climate System

2.1 By utilizing the Grid Point Values of the GMS-4 IR radiance data, the global climate system is being monitored by the Long-range Forecast Division, Forecast Department, JMA.

2.2 Consecutive five-day averages are computed from the three-hourly measurement data at each 2.5- by 2.5-degree grid for equivalent black-body temperature (TBB) and at each 1.0- by 1.0-degree grid for high-cloud amount, respectively. Using these five-day averages, monthly means (consecutive 30-day averages; for August 35-day average) and seasonal means (three-month averages) for TBB and high-cloud amount, and high-cloud amount anomalies from 13-year averages (from 1978 to 1990) are prepared.

2.3 The data are being used for analyzing the monsoon activities, the interannual variations (*e.g.*, ENSO) and the intraseasonal variations ranging from 30 days to 60 days in the tropics, and the activities of the frontal zone around East Asia.

Estimation of Total Ozone Amount from NOAA/TOVS data

2.4 A technique for the estimation of total ozone amount from TOVS data was developed to use as a quick monitoring of ozone distribution near Japan. The technique is based on the regression method considering HIRS's channel 9 (9.6 mm), *i.e.*, the spectral band of ozone absorption. Input data are radiances of five channels, *i.e.*, ch. 1, 2, 3, 8 and 9 of HIRS. The regression coefficients are determined by the co-located data from satellite observations and the Dobson measurements at the four JMA's surface observation stations; Sapporo, Tateno, Kagoshima and Naha.

Volcanic Eruption Clouds from Mt. Pinatubo, Philippines

2.5 This century's largest volcanic eruption occurred in the Philippines, Mt. Pinatubo on 15 June 1991, being accompanied by gigantic volcanic eruption clouds (VECs). The extent of the VECs was monitored by the GMS-4 hourly observation. The development and dispersal of VECs were analytically studied using GMS-4 hourly visible and infrared images.

Detection of Fog using NOAA/AVHRR Data

2.6 A technique for the detection of fog distribution in the nighttime over the sea was developed based on the emissivity difference at the top of fog between 3.7 mm and 11 mm spectral bands, which is nearly equal to the difference of brightness temperatures between channel 3 and channel 4 of AVHRR on NOAA satellite.

2.7 The preliminary studies of the algorithm showed that satellite-derived fog distributions are in good agreement with those by the surface observation. The studies suggest the possibility of an operational utilization of this technique in the MSC's neph-analysis.

Estimation of Solar Irradiance at the Surface

2.8 Solar irradiance at the surface is estimated by a regression method using GMS visible data. The regression coefficients are determined from a data-set, which is composed of pairs of satellite data and pyranometric data, co-located spatially and temporary. The pyranometric data are made from solar irradiance observed at 15 meteorological observatories of the JMA.

Extraction of Cirrus Cloud Parameters from the Infrared 10 mm Window Radiances

2.9 The 10 mm window channels of NOAA-11 and the spectral distribution of downward atmospheric radiances that were measured by FTIR spectrometer from the ground were analyzed to investigate the possibility of cirrus cloud parameters extraction from the radiances in the 10 mm window region. The observed spectra were compared with simulated ones that were computed assuming spherical ice particles with the power law size distributions measured by Hydrometer Video Sonde (HYVIS).

2.10 From the comparison of FTIR radiances with simulated ones, the IR optical thickness at l = 10 mm and lower limit sizes of the power law distribution were estimated. The brightness temperature differences between channels 4 and 5 of AVHRR, and those between channels 8 and 10 of HIRS on NOAA-11 satellite were compared with those computed for model ice clouds. The satellite brightness temperature mostly scattered between calculated values with the lower-limit sizes of 4 mm and 16 mm. These results indicate that the radiances in the 10 mm region include the information on size distribution of cloud particles and that there is a possibility of extraction of cloud parameters.

Sensitivity of Shortwave Radiation to Cirrus Parameters

2.11 To improve a monitoring technique for estimating the shortwave radiation absorbed in the ocean (I_{abs}) from space, sensitivity of I_{abs} to cirrus parameters were investigated in a model atmosphere-ocean system in the wavelength region ranging from 0.285 to 5.0 mm. The cirrus was assumed to be composed of hexagonal ice crystals (columns and plates). The effects of orientation of crystals were also estimated. Numerical simulation showed that the type and orientation of ice crystals cannot be neglected to achieve the accuracy of 10 W/m^2 that is required for climate understanding.

Validation Experiments for Oceanic Phenomena found in SAR Images

2.12 Several cruises by the JMA research vessels have been carried out to make simultaneous observations with the European ERS-1 SAR observations, and further cruises are planned for both European and Japanese ERS-1 SAR observations. These experiments will provide sea truth data such as ocean waves, small scale surface roughness, ocean current, and atmospheric parameters, which are essential for analyzing phenomena observed by SAR. These cruises will be carried out around the Japanese Islands several times per year.

Precipitation derived from Passive Microwave Radiometer

2.13 An algorithm for retrieving precipitation over the ocean from the data of Special Sensor Microwave/Imager aboard the U.S. Defense Meteorological Satellite Program was developed, and a worldwide map of precipitation over the ocean was made for one year from July 1987 to June 1988.

PART III A description of techniques development in the applications of satellite data, derived products and services

Technique for Typhoon Genesis Judgement using GMS Imagery

3.1 A technique was studied to detect the information related to the development of tropical depression using GMS imagery, especially typhoon genesis within 24 hours. The cloud types and the cloud distribution patterns around tropical depression in GMS imagery were manually analyzed and quantified to use statistical analysis. The parameters, "Cb parameter", "Band parameter (for curved band pattern)", "DO parameter (for dense cloud overcast pattern)" and "Ci parameter" were selected for further study.

PART IV System for satellite applications in operational use

Data Utilization at JMA

4.1 GMS imagery data are distributed from the MSC to the JMA Headquarters and relevant local offices for use in their services. The main distribution routes and the data utilization are as follows:

JMA Headquarters

(a) High-resolution imagery

High-resolution imagery data are transmitted from MSC on the JMA's microwave circuit to the Headquarters. The data are taken into the satellite imagery handling equipment in the Forecast Department, which is composed of a minicomputer. Sea ice forecasters use the stored imagery data reproduced on CRT displays.

(b) Low-resolution imagery

Low-resolution imagery data are also sent to the Headquarters, and mainly used for watching weather conditions by such means as computer loop movies.

Local installations

4.2 WEFAX direct receivers are equipped to receive low-resolution imagery at ten forecast centers, four Marine Observatories and six Aviation Weather Service Centers/Stations. The received data are used in a similar way to that in the JMA Headquarters.

4.3 In addition to the imagery, secondary derived data are distributed to the JMA Headquarters and relevant local offices through the JMA's land line network and Automated Data Editing and Switching System (ADESS). The distributed products include satellite cloud information charts, index of precipitation intensity, cloud motion wind vectors, VISSR grid point data (*e.g.*, cloud amounts, mean cloud-top temperature, etc., at each 0.5-degree mesh) and sea-surface temperature.

Application to Marine Meteorological Data Collection of *in situ* Observations

4.4 The JMA is operating six observation/research vessels equipped with the DCP system. The JMA is collecting maritime meteorological and oceanographical data from these vessels via the DCP system, and aerological data from three of them.

4.5 The JMA is also collecting shipboard weather radar data from two vessels via the DCP regional frequency band. The system diagram is shown in Fig. 1. Summary of the DCP specification is as follows:

Frequency	:	one of the DCP regional channel (Time division transmission)
Bit rate	:	1200 bps
Modulation	:	4-QPSK
Transmitting Data	:	Echo intensity, height of echo tops, accumulated hourly radar precipitation

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

Plans for GMS-5

5.1 GMS-5 is under development and fabrication, and is scheduled for launch in early 1994. GMS-5 will have additional observation spectral bands beyond the current satellite as summarized in Table 1. GMS-5 will also have an experimental search and rescue equipment to relay distress signals.

Table 1 Observation Spectral Bands

Observation Spectral bands	GMS-4	GMS-5
visible	0.50 to 0.75	0.55 to 0.90
infrared (thermal)	10.5 to 12.5	10.5 to 11.5 11.5 to 12.5
infrared (water vapor)	None	6.5 to 7.0

(units: micro-meter)

Product Plan of GMS-5

5.2 It is planned that modification of the ground communication system and replacement of the computer system in the Meteorological Satellite Center (MSC) will be performed before the GMS-5 launch, and also various products of MSC (see Table 2) will be improved using the above mentioned sensors and disseminated to users via GMS-5 or GTS. Major products are described as follows:

- All VISSR data will be disseminated to MDUS users via GMS-5 and dissemination format will be the same as the current one with slight modification, i.e. water vapor and split window data will be added to the current S-VISSR.
- On the WEFAX broadcast schedule, sectorized water vapor images will be broadcasted twice a day in addition to the current schedule.
- Satellite winds at middle level of atmosphere will be derived using water vapor images. Low level and high level cloud motion winds will continue to be derived, and improvement of accuracy for height assignment through water vapor images is planned. Those data will be disseminated via GTS.
- Sea surface temperature will be estimated with better accuracy than the current one, as the amount of water vapor, the main source of SST error, could be estimated from the temperature deference of the split window channel data.
- Cloud amount will continue to be derived using one channel of the split window. We plan to slightly improve them by using finer vertical profiles from numerical weather prediction forecasts.
- One channel of the split window will be used to process Equivalent Black Body Temperature. The processing method will not be changed.
- Upper-air humidity data will be newly made from a combination of water vapor data and one channel data of the split window.
- Precipitable water data will be newly made from both channel data of the split window.
- Center location of Typhoon and intensity of typhoon will continue to be estimated by operators.
- WCRP data (ISCCP and GPCP data) will continue to be archived.

Table 2 Planned Product for GMS-5

Product Name Resolution	Frequency	Horizontal	Region
Broadcast			
Stretched-VISSR VIS	Hourly	1.25 km at SSP	Full Disk
	WV "	5.0 km at SSP	"
	IR1 "	"	"
	IR2 "	"	"
WEFAX			
Polar	IR1 Hourly	1710x800 Pixels	Far East Asia/ western Pacific
	VIS Hourly	"	"
Four-sectorized	IR1 3-hourly	"	4 sectors
Rectified Disk	WV1 12-hourly	"	"
Satellite Wind			
low-level	6-hourly	1.0° Lat./Lon.	50°N-50°S, 90°E-170°W
middle-level	"	"	"
high-level	"	"	"
Sea Surface Temperature	5 days	0.5° Lat./Lon.	50°N-50°S, 90°E-170°
W			
Upper Air Humidity	6-hourly	"	"
Precipitable Water	6-hourly	"	"
Cloud Amount	5 days	"	60°N-60°S, 80°E-160°W
Equivalent Black Body Temperature	3-hourly	"	"
Typhoon Analysis			
Location of Center	3-hourly	-	North of the equator
Intensity	6-hourly	-	100°E-180°E

Remarks: SSP = Sub-Satellite Point

PART VI Validation and verification of satellite data and derived products

GMS high-level wind

6.1 The height assignment look-up table for GMS high-level Cloud Motion Wind (CMW) was revised in April 1990. Furthermore, the manual quality control procedure was modified in April 1991 and operators can change the statistically assigned height. This operation is effective in the vicinity of the Jet Stream in the northern hemisphere.

6.2 In order to evaluate the modification of height assignment method, the monthly mean difference between CMWs and rawin winds were calculated in the same way as the International Comparison of Satellite Winds. Speed bias from January 1989 through April 1992 are shown in Figs. 2 (a) and (b).

6.3 An improvement was seen after the introduction of the new height assignment table in April 1990. A further improvement by the modification of wind height in the manual quality control process can also be seen after April 1991. The speed bias of CMWs to rawin winds was reduced by 2 m/s after April 1990. The current bias after April 1991 is less than 2 m/s.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7.1 Publications

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Kigawa S.: A Newly-developed Technique of Image Mapping: Distortion Data Determination based on the Earth Edge Detection from Infrared Half Disc Image.

Meteorological Satellite Center, 1990: Technical Note of Meteorological Satellite Center (in Japanese with English Summary), No. 23, 82pp.

Tokuno M.: GMS-4-Observation of Eruption Clouds from Philippine Volcano Pinatubo (in English).

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Nishida T., Y. Ohashi and K. Sekine; Process and Consideration of Solar Panel Current of GMS-3/4 Using Solar Panel Current Regularization Program.

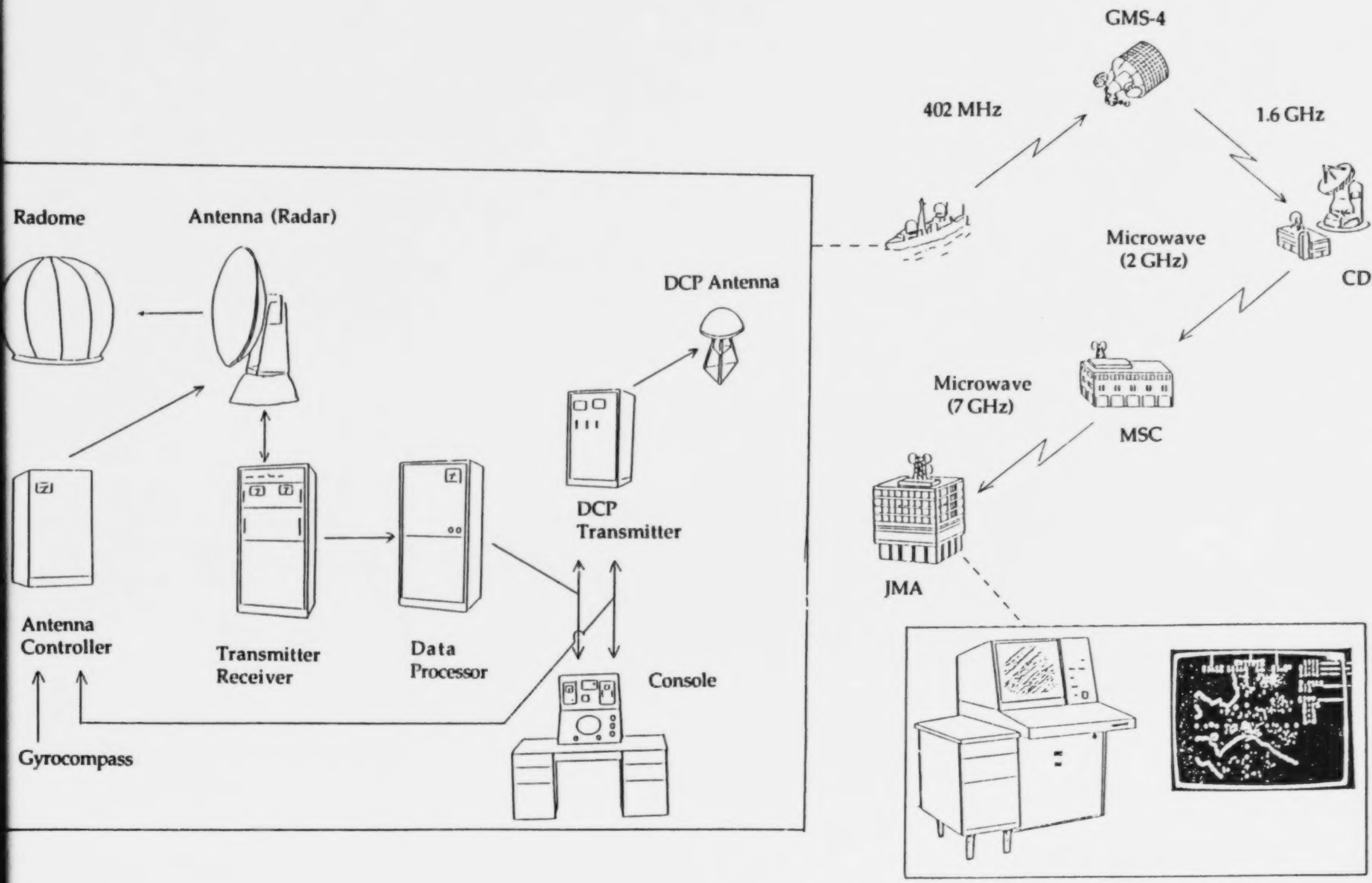

Fig. 1 System Diagram of Ship's Radar Observation.

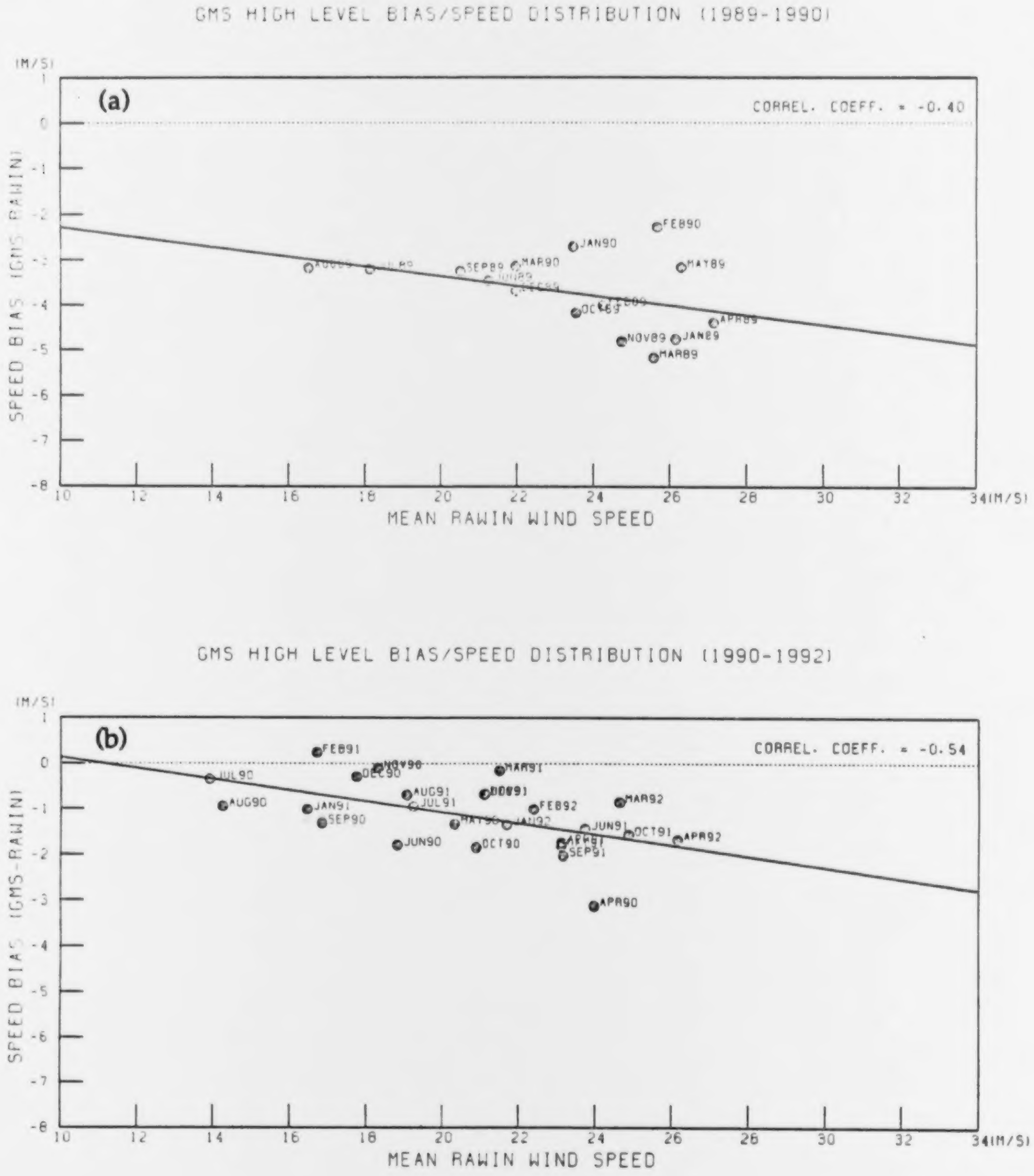

Fig. 2 Monthly means of speed bias between CMW and rawin wind:
(a) from January 1989 to March 1990, and (b) from April 1990 to April 1992.

KENYA

Meteorological Department

PART I Summary of the major highlights of research applications and operational changes

1.1 This report gives a brief resume of the current status of the satellite receiving equipment within the Kenya Meteorological Department (KMD) and various aspects in applications of satellite technology in meteorology as an aid to weather forecasting and drought monitoring.

1.2 It also touches briefly on the future plans for the satellite facilities within KMD.

PART II Major research and development in the applications of satellite data, derived products and services

2. A lot of scientific research is presently being carried out by both the department's personnel and the other end users (mainly from the remote sensing centres within the country and the university students) using satellite derived information. Meanwhile, there have been a number of requests for the NOAA images but due to our limitations in applications software we have not managed to honour all the requests. We are at the moment producing NDVI images to all our end users' within the country plus raw images on cassette cartridges to ESA on monthly basis.

PART III A description of techniques development and applications of satellite data, derived products and services

IMAGE DATA-BASE

3.1 The HRPT and PDUS facilities are currently capable of receiving and processing images on all available channels from both NOAA satellites and the METEOSAT.

HRPT STATION

3.2 The HRPT station was installed in Nairobi in May, 1988 with an expected areal coverage from latitude 22 degree North to 25 degree south and longitude 12 to 60 degree East, allowing for excellent coverage of Eastern Africa.

3.3 Presently, it is capable of acquiring images on channel 1 - 5 plus the TIPS (e.g. TOVS etc.) which are archived daily on exabyte cassette cartridges for local use as an internal data-base and to other remote sensing centres in the country. These cassettes are later on sent to the European Space Agency (ESA) for storage on a monthly basis.

3.4 Development of applications software is currently being undertaken in conjunction with the Agrhymet Centre in Niamey, Niger.

PDUS STATION

3.5 The PDUS station was installed early 1990 and is now receiving full imagery from the METEOSAT satellite every half hour.

3.6 The station is fitted with a video display unit with software for displaying images.

3.7 Using these facilities, it has been possible to get colour enhanced images ,blow-ups and animation of the images on 8 hourly basis.

3.8 The pictures are particularly useful in aiding analysis of conventional data especially detecting the position of the ITCZ, the frontal systems together with the cyclones and for public weather forecasting.

PART IV System for satellite applications in current operational use

4.1 The HRPT processed NDVI images are currently being used by the Drought Monitoring Centre (DMC) and the Department of Resource Surveying and Remote

Sensing (DRSRS), both in Nairobi . The FAO project hopes to use these images in their various projects such as the early warning system for food security as soon as a micro-wave link is established.

4.2 The Meteosat images are expected to be useful in rainfall estimation and as data-base for future use. Calibration and Map-projections of these images has already been undertaken.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Establish KMD as a regional centre for image acquisition and pre-processing of satellite data. A microwave link for disseminating both raw and processed satellite images to other remote sensing centres within Kenya has been already established to one of these centres (DRSRS) and we hope to establish another link with the Regional Centre for Services in Surveying , Mapping and Remote Sensing (RCSSMRS) towards the end of 1992.

5.2 Develop application software for processing the satellite images for various end users.

5.3 Acquire another PDUS system which will be mainly dedicated to research and training at the RMTC Nairobi. It will also be used by the Drought Monitoring Centre on a day-to-day basis.

REPUBLIC OF KOREA

PART I Summary

1. In 1991, there were no major operational changes except that analog laser facsimile recorders were installed at Taejon Regional Meteorological Office and Kimpo Aeronautical Meteorological Station, respectively to print out low resolution images of GMS. On the research side, four research works are projected and two of them have been accomplished. The other two research works will he continued till 1992 - 93. (See also part II and III)

PART II Research

2.1 A study on the combined meteorological information system is undertaken Contents are as follows :

- Study for the improvement of meteorological information service,
- Development of the overlay S/W between synoptic data and satellite data.

2.2 A study on the development of short range precipitation forecasting system using satellite and radar observations is undertaken. Main tasks are as follows :

- Improvement of the pre-processes of satellite and radar observations,
- Standardization of satellite and radar observation data formats for regional use,
- Development of a method of integrating the information for precipitation analysis.

PART III Techniques Development and Applications

3.1 The main works are directed toward applications of satellite data for weather monitoring, analysing and forecasting. A study on rain by merged cloud systems using satellite images was accomplished. Details are as follows

- Correlation between the area of cloud mergence and rain area,
- Investigation of features of clouds accompanying mesoscale weather phenomena,
- Proposal of cloud patterns accompanying synoptic pressure patterns.

3.2 Comparison and analysis of TOVS retrieved outputs with the RAOB has been done. Main parts are as follows

- Emphasis on analysing the root mean square difference (RMSD) and the bias between TOVS outputs (temperature, dewpoint temperature and mixing ratio) and corresponding RAOB,
- Analysis of upper air state over the Korean peninsula using TOVS outputs.

PART IV System for satellite applications to meteorology and operational hydrology

4.1 In addition to the already existing facilities displaying the hourly cloud imagery of GMS through real time system for distributing satellite image, analog laser facsimile recorders were installed and are under operation at Taejon regional meteorological office and Kimpo Aeronautical Meteorological Station respectively to print out L-R images of GMS via telephone lines.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 None at the present time.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6.1 See also part III 3.3.

PART VII Other items (references, publications and the names of scientists in charge, etc.)

7.1 Publications

Ik-Su Kim, A study on the combined meteorological information system (II). Ministry of Science and Technology (MST) Special Report (1991), 486 pp.

Hee-Seung Choi, A study on the development of very short range precipitation forecasting system using satellite and radar observations (I). MST Special report (1991), 175 pp.

Chung-Whan Rah, A study on rain by merged cloud systems. Meteorological Research Institute (MRI) Report (1991), 167 pp.

Hak-Soo Yoon, A study on the comparison and calibration of the TOVS data, and analysis of upper air state over Korea by TOVS outputs. MRI Report (1990), 100 pp.

MALAYSIA

(Malaysian Meteorological Service)

PART I Summary of Major highlights of research applications and operational changes

1. There was no major operational change in 1991. However, with the breakdown of the NOAA receiving system, there was no reception from the NOAA satellite. The Medium Scale Data Utilization Station (MDUS) continued to receive, at hourly intervals, the GMS S-VISSR digital data.

PART II Research and Development

2. GMS satellite images were utilized to delineate areas in SE Asia affected by haze which was identified to have emanated from forest fires in Southern Sumatra and Kalimantan.

PART III Technique Development

NIL

PART IV System in Operational Use

4.1 The METDAS acquisition system continued to receive and process the S-VISSR hourly digital data transmitted by the Japanese GMS satellite. These satellite data were transferred to CCT for permanent archive. Satellite images generated were disseminated to the various Forecast Offices for the routine preparation of daily weather forecast. Total number of satellite imageries produced in 1991 was 4770 pictures.

4.2 No products were generated by the TIROS-N (NOAA) satellite system in 1991 due to system breakdown.

4.3 An LRFAX System received low resolution WEFAX transmissions from TGMS. It was used as a backup system to the METDAS. Total number of pictures produced by this system in 1991 was 380 pictures.

PART V Plan for Future Operational System

5.1 An upgrade for the receiving and processing facility of NOAA-AVHRR data would be acquired by the end of 1992. The upgraded system would be able to receive both NOAA-AVHRR imaging and sounding (TOVS) data for the enhancement of local weather analysis and forecasting.

PART VII Other items (contact)

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46667 Petaling Jaya
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THE NETHERLANDS

Royal Netherlands Metorological Institute (KNMI)

PART I Summary of the major highlights of research applications and operational changes

1.1 A new integrated PDUS and HRPT system has been installed and taken in operation at KNMI during 1991.

1.2 Meteosat images are used on a routine basis as an interactive aid in weather forecasting.

1.3 Research and development has been done on a variety of fields. They include image products, TOVS retrieval, ERS-1 winds and altimeter data. These projects aim at an improved understanding and use of satellite data in the context of operational meteorology.

1.4 For climate research and monitoring purposes data from TOVS, ERS-1 and ISCCP are used.

1.5 The institute takes part in the development of retrieval algorithms for data from instruments to be flown on future platforms.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 NOAA-AVHRR

KNMI has developed, together with Divisions of Rijkswaterstaat, several image products and applications for land and sea surfaces, based on NOAA-AVHRR data:

-Sea Surface Temperature (SST) maps of the North Sea,
-Total Suspended Matter (TSM) concentration maps of the North Sea,
-Monitoring of floating layers of Blue Algae on the IJsselmeer,
-Monitoring of ice cover in the IJsselmeer,
-Vegetation Index (NDVI) maps of the Netherlands and part of the surrounding countries,
-Land Surface Temperature (LST) maps of the Netherlands.

Image products are produced and archived on a routine basis and used by external users in their operations. KNMI has developed a public domain software package ("NOAAPC") to be run on MS-DOS PC-systems for display and analysis of the image products of KNMI.

2.2 NOAA-TOVS

Since the beginning of the year 1991 a TOVS-processing suite is operational. The processing starts from the raw data reception in the Institute's HRPT station and includes all the necessary steps to produce retrieved temperature and humidity profile information.
The calibration and navigation steps employ international standard routines, whereas the 3I-system developed by the Laboratoire de Météorologie Dynamique (LMD) in France has been implemented as the retrieval scheme. The resulting 1000 - 500 hPa thickness maps are used as a monitoring tool.

A special development has been undertaken to ensure that unreliable data are detected at the earliest possible moment in the processing chain. To achieve this parity and format controls are exploited as much as possible in the checking and extraction of the incoming data.

A strong collaboration with the LMD is maintained to exploit our routine validation results in new developments of the 3I-algorithm. Activities for the assimilation of retrieved TOVS data into the institute's High Resolution Limited Area Model (HIRLAM) and for studying their impact on operational forecasts have been defined and will be implemented in the near future.

2.3 ERS-1

Impact studies of ERS-1 data assimilated operationally in HIRLAM are under way at KNMI. ERS-1 10 metre winds are introduced into the HIRLAM analysis scheme as a new subtype of drifting buoy data. The high density and high resolution of the data necessitate the formation of super-observations of this new data type. This is achieved by minimal changes to the HIRLAM assimilation code. Research into the improvement of the analysis of asynoptic, single-level, highly correlated data such as ERS-1 winds is on-going.

In the VIERS project a physical model for the scatterometer-wind retrieval is developed using observations over sea. The assimilation of ERS-1 wind data in the NEDWAM wave model for the North Sea area has shown a positive impact on the analysis. A positive impact on the wave forecasts has not been found yet. An improved semi-empirical retrieval method that takes into account the wave-age is tested in a global wave model (WAM) in cooperation with ECMWF. Alongside this effort the aim is to set up a global database of air-sea fluxes to be used in climate research.

2.4 Other research and development projects.

The Institute is actively involved in parts of the national environmental and climate research program. In this context a project has been started aiming at validation of ISCCP- and ERBE-algorithms, especially the cloud-detection parts, and at the understanding of the error characteristics of these algorithms. Where possible refinements of the schemes will be proposed with emphasis on the reduction of systematic errors. Furthermore, ISCCP cloud observations are used to estimate the cloud diabatic forcing of the atmosphere.

A start has been made with the use of TOVS radiances for monitoring the total stratospheric ozone content. In the context of the preparation of the ERS-2 satellite, the Institute is participating in the development of retrieval algorithms for GOME (Global Ozone Monitoring Experiment). Emphasis is on the information that can be obtained for scattering particles in the atmosphere (aerosols and cloud particles) from detailed knowledge of the spectral distribution observed by this instrument.

PART III Techniques development and applications of satellite data, derived products and services

PART IV Description of the system for satellite applications in current operational use

4.1 A new integrated system for reception, processing and presentation of METEOSAT (PDUS) and NOAA (HRPT) satellite data has been installed at KNMI in 1991. The system, delivered by VCS Nachrichtentechnik GmbH in Bochum, Germany, consists of a cluster of VAX-stations connected via an Ethernet-link.

The reception and processing of METEOSAT and NOAA data is performed by two VAX 3400-stations (VMS operating system). Four workstations (being composed of one VAX 3100-station and one 386-PC each) are connected for the presentation of image products in the operational weather forecasting offices (De Bilt, Schiphol, Hook of Holland and the TV-studio in Hilversum).

A MicroVAX is available for the routine processing of TOVS-data and another MicroVAX (equiped with a graphics workstation) for the processing of sea and land surface products (SST, NDVI etc.).

Several MicroVAXes, VAX-workstations and PC-systems, which are used for research and development, are connected to the central system.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 The infrastructure for the use of meteorological satellite data is now nearly optimal. In the near future KNMI will put more effort in the development of new methodologies, products and applications to make a better use of this infrastructure at KNMI. Special attention will be paid to a better use of presently available satellite data in the operational weather forecasting (by data assimilation in numerical models and by education of the meteorologists; see also under parts 2 and 6).

5.2 Co-operation between LMD and the Institute for Meteorology and Climate Research (IMK, in Karlsruhe, Germany) has been started to undertake research in the possibilities of including high spatial resolution imager (AVHRR) data within the 3I-TOVS retrieval scheme.

5.3 The possibilities of combining TOVS, AVHRR and METEOSAT products into a (semi-)automatic very short range cloud and precipitation forecast method are studied.

5.4 In the near future a lot of manpower will be put in the use of satellite data in climate research. KNMI will participate in large studies financed by the EC (e.g. the monitoring of desertification in the Mediterranean area using meteorological satellites).

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

Monitoring of TOVS results

6.1 A pilot study has been performed as a basis for the definition of a routine validation scheme as part of the TOVS processing. Currently for every satellite overpass a map of the results for the 1000-500 hPa thickness is plotted, used as quick look for gross problems in the processing. Furthermore tools for comparison with radiosonde-ascents are available, but these are not yet used routinely.

6.2 Developments are underway to use the retrieved upperair information in the data-assimilation step of the operational LAM. Error statistics will be gathered from this excercise.

6.3 Definitions for further international projects (with e.g. LMD and IMK) are underway. These projects will aim at the integration of the available scientific knowledge on TOVS, AVHRR and terrain models with operational experience into a new, (pre-)operational satellite data processing system, that will draw on the strong points of each available instrument to narrow down the errors observed in current retrieval schemes.

Verification of ERS-1 data

6.4 An intercomparison of ERS-1 altimeter wave height data and NEDWAM wave forecasts is under way.

6.5 The evaluation of ERS-1 winds in continuous parallel tests has been hampered by problems in the processing and dissemination of the data by ESA, leading to gaps in the data or data arriving too late to be used in assimilation. Furthermore, the quality of the wind data received, especially the wind direction, is at present questionable. A proper evaluation of the benefits of ERS-1 wind data assimilation and their operational implementation will have to await improvements ESA is planning to make on the retrieval of 10 metre winds.

PART VII Other items (references, publications and names of scientists in charge, etc.)

Scientists in charge.

TOVS R&D, processing and data assimilation

1. Dr S.J.M. Barlag

2. Dr G.J. Prangsma

ERS-1 R&D, processing and data assimilation

3. Dr B. Wichers Schreur

4. Dr P.A.E.M. Janssen

5. Dr W.A. Oost

AVHRR R&D, processing

6. Dr J.N. Roozekrans

ERS-2/GOME studies

7. Dr P. Stammes

ISCCP/ERBE studies

8. Dr A. J. Feijt

Publications

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A squall line over South-Western France: 7 June 1987. Description of the synoptic situation preceeding the afternoon event. G.J. Prangsma, in: "Technical Proceedings of the Fifth International TOVS Study Conference", July 1990, Toulouse, pp. 303-312

Towards a TOVS cookbook. A guide for real-time TOVS users?. G.J. Prangsma, in: "Technical Proceedings of the Sixth International TOVS Study Conference", 1-6 May 1991, Airley, Virginia, pp. 396-400

Observatie van het aard-atmosfeersysteem door de NOAA-satellieten (ontvangst, productie, toepassing en gebruik van de NOAA-data). J.N. Roozekrans and G.J. Prangsma. BCRS Report 92-02 (ISBN 90 5411 034 1, in dutch).

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Wave data assimilation for operational wave forecasting at the North Sea. G. Burgers, V. Makin, G. Quanduo, M de las Heras, 3rd International Workshop on wave hindcasting and forecasting, May 1992, Montréal, Québec.

PAKISTAN

Pakistan Meteorological Department

PART I A summary of the major highlights of research applications and operational changes

1. This report summarises the satellite applications in the functional area of transmission of satellite data through direct broadcast modes. Meteorological Satellite Ground Receiving Equipment installed at Karachi, Lahore are operationally receiving APT pictures of NOAA polar orbiting satellites and that at Islamabad receives APT pictures of METEOSAT also. Satellite pictures are used in the daily weather analysis and forecasting (public, aeronautical and marine).

PART II Major research and development and applications of satellite data, derived products and services

2. No specific research projects were undertaken by Pakistan Meteorological Department so far. However, individual researchers use satellite pictures for their studies.

PART III Description of techniques development and applicaations of satellite data, derived products and services

3. A combination of pictures (Infrared, Visible) are used in determining cloud systems, areas of convection, synoptic weather system, location of tropical cyclone and determining its size, intensity and movement. Satellite picture is also used in national Television Weather Broadcast for public.

PART IV System for satellite applications in current operational use in 1991

4.1 Pakistan Meteorological Department (PMD) operates a network of five APT ground receiving stations located at Weather Central Karachi, Meteorological Office, Karachi Airport, Flood Forecasting and Warning Centre, Lahore, Meteorological Office, Lahore Airport and Main Analysis Centre (MAC), Islamabad. These Meteorological Satellite Ground Receiving Equipment have been manufactured by Space Technology Systems Ltd. of UK. The APT ground receiving stations located at Weather Central Karachi, Forecasting Office, Karachi Airport, Flood Forecasting and Warning Centre Lahore and Forecasting Office, Lahore Airport receive cloud pictures from NOAA polar orbiting meteorological satellites whereas that at MAC Islamabad receives APT pictures of METEOSAT also.

4.2 These APT ground receiving stations have presently limited capability of acquiring cloud pictures and to some extent temperature of cloud also. Cloud pictures received are being utilised by PMD Forecasting Offices at Karachi, Lahore and Islamabad for operational weather analysis and forecasting such as preparation of significant weather charts, SIGMET information, local met. warnings, movement and identification of weather systems like cyclones, depressions, frontal weather systems. The APT systems installed at Weather Central Karachi and at Meteorological Offices Karachi and Lahore Airports are exclusively used for aeronautical forecasting whereas the System at Flood Forecasting and Warning Centre Lahore serves dual purpose i.e. Aeronautical as well as Operational Hydrological Forecasting which includes the estimation and issuance of qualitative precipitation forecast for the calculation of runoff. This System is particularly extremely helpful in the identification of various clouds systems (both tropical and extra tropical cyclones), their intensity and movement. APT pictures were also supplied to various national and international air services for their enroute flights to ensure safety of their aircrafts from severe weather system. Requests were also received from local newspapers for supply of APT pictures for information and use by the interested scientific departments and for public awareness about weather. Satellite imagery is presently being used at the Main Analysis Centre (MAC) Islamabad as an aid to weather forecasting. This is invariably used in two ways with correlation to synoptic and upper-air meteorological data analysis. Firstly, in case of prevailing weather system or likely to prevail in near future, the temperatures at the point location are utilised in estimation of cloud tops and up to some extent cloud genesis. Secondly, for short to somewhat medium-range forecasting, the system approaching the country/territory are analysed with respect to temperature-slice density along with the zooming facility, the track of the system is determined accordingly with upper-air wind and surface pressure pattern. The above facility is only limited with NOAA imageries.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5. Pakistan Meteorological Department intends to strengthen the network of APT ground receiving stations. Non-availability of direct read-out from INSAT series is, however, a major handicap.

PART VI Validation and verification of satellite data and derived products used in operations

6. No system for validation and verification of satellite data is presently in operation in Pakistan Meteorological Department.

PART VII Names of scientists in-charge

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(d) Senior Meteorologist
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(e) Senior Meteorologist
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PHILIPPINES

Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA)

PART I Brief summary of the major highlights of research applications and operational changes

1.1 Since the end of the third quarter of 1991, the PAGASA had two meteorological satellite receiving and processing systems with the commissioning of the NOAA-AVHRR receiving and processing facility donated by the Australian Government. However, for the rest of 1991 the activities related to the NOAA-AVHRR system were confined to the training on both the operation and maintenance of the system and the application of AVHRR data. A series of modular trainings on advance applications had been programmed up to the end of 1992 to be conducted by experts from the Bureau of Meteorology of Australia.

1.2 Throughout the year 1991, the Geostationary Meteorological Satellite (GMS) S-VISSR ground receiving system continued receiving hourly data which are immediately processed to yield imageries or pictures. The animation composed of 36 frames and the application of enhancement techniques were heavily used in the analysis and interpretation of weather changes especially over the data-sparse oceanic areas around the Philippines. The use of satellite data and information was still primarily for operational weather forecasting such as for aviation, shipping and the general public.

PART II Description of major research and development in the applications of satellite data, derived products and services

2. A study on the use of S-VISSR and AVHRR data in the estimation of rainfall amount, which is conducted by Ms. Flaviana Hilario of the Climatology Branch, is in progress.

PART III Description of techniques development and applications of satellite data, derived products and services

3.1 The basic technique for tropical cyclone forecasting which continue to be used is the Dvorak Model. A combination of visible and infrared imageries are used in determining cloud systems, areas of convection, synoptic weather systems, location of tropical cyclone and determining its size, intensity and movement.

3.2 Satellite-derived cloud drift winds for the 850 hpa and 200 hpa level are still made available by JMA through GTS. These data are useful in streamline analysis.

3.3 A hardcopy of a colored S-VISSR imagery continue to be provided for use in television broadcast.

PART IV Description of the system for satellite applications in current operational use

4. Aside from the basic GMS S-VISSR Ground Receiving System which is currently in operation, the NOAA-AVHRR receiving and processing facility was put into operation late this year. The NOAA-AVHRR system is composed of a ground-based tracking equipment, an ingest computer, a Director's terminal and two work stations for AVHRR and TOVS data processing. The second workstation, upon its arrival, will be installed right at the forecasting center for use by operational meteorologists.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Establish a real-time TOVS processing capability for operational use.

5.2 Examination of the use of cloud top temperature anomaly to estimate the intensity of tropical cyclones.

5.3 Enhance the utilization of GMS S-VISSR data through the use of application softwares available for the NOAA-AVHRR system.

5.4 Study the applicability of TOVS-derived soundings for the analysis of meso-scale weather systems.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6. Not yet undertaken in 1991 but plans to verify as well as introduce a correction factor for TOVS data are underway.

PART VII Other items (references, publications and name of scientists in charge, etc.)

Names of scientists in charge:

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3. Mr. CARMELITO CALIMBAS
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4. Mr. PRISCO D. NILO
Senior Weather Specialist
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SAUDI ARABIA

PART I Summary of major highlights of research applications and operational changes

1. The Meteorology and Environmental Protection Administration (MEPA) of the Kingdom of Saudi Arabia has three stations to receive meteorological and environmental data from the geostationary and polar orbiting satellites. The location, the hardware utilised and satellite types are described in the Table given below.

Station	Hardware Manufacturer	Satellite and Data Type	
Jeddah	TECNAVIA	Meteosat and Polar Orb.	VIS, IR, WV Imagery
(21.7N; 39.2E)	DETWILER	Meteosat and Polar Orb.	VIS, IR, WV Imagery
	LUT (Microlag Corp)	Polar Orb.	Buoy Data
Biyadh (24.9N; 46.7E)	CIR	Meteosat and Polar Orb.	VIS, IR, WV Imagery
Bhahran (26.1N; 50.1E)	DETWILER	Meteosat and Polar Orb.	VIS, IR, WV Imagery

All the stations except LUT in Jeddah receives high resolution and low resolution satellite cloud pictures at the usual frequency (IR every 30 minutes, VIS and WV at main synoptic hours). Jeddah is the Primary Data Utilization Station (PEUS) and Riyadh and Dhahran are the Secondary Data Utilization Stations (SDUS) for the Geostationary satellite imagery (Meteosat). LUT station in Jeddah is used for receiving surface data from the buoys deployed in the Arabian Gulf.

SINGAPORE

PART I SUMMARY OF THE MAJOR HIGHLIGHTS OF RESEARCH, APPLICATION AND OPERATIONAL CHANGES

1. The satellite data receiving system is now linked to a new graphic workstation network installed in 1991. Data received are transferred automatically to a server in the network. Users at remote stations can now use a workstation connected to the network to display and analyse the raw imageries as well as the derived products (such as cloud top, sea surface temperature analyses). The satellite data can be shown together with weather charts and NWP products that are stored in the network.

PART II MAJOR RESEARCH AND DEVELOPMENT

2. Tests have been carried with the humidity profiles from TOVS data to improve the input moisture field in NWP. Similar tests were also carried out using humidity profiles derived from GMS IR data. Initial results have been quite encouraging.

PART III TECHNIQUES AND APPLICATIONS OF SATELLITE DATA, DERIVED PRODUCTS AND SERVICES

3.1 Received satellite imagery is used operationally to forecast weather conditions for aviation, shipping and the public.

3.2 Image enhancement techniques are being developed on GMS and NOAA imagery to delineate areas enveloped by thick haze and volcanic ash.

3.3 Products like sea surface temperature and height of cloud tops are derived from GMS data for operational use.

3.4 Archiving of data on 1 2-inch optical disks is being done to support operational requirements and research.

PART IV DESCRIPTION OF OPERATIONAL SYSTEM

4.1 The system consists of GMS and HRPT reception sub-systems, 2 dedicated Micro-VAX 11 minicomputers and a special image processing sub-system.

4.2 The display system comprises a high resolution GEM 35 workstation and a remote display sub-system. Hardcopy output devices include laser fax recorder, colour printers, plotter and photographic copier.

PART V PLANS FOR FUTURE OPERATIONAL SYSTEMS

5.1 It is planned to incorporate both the TOVS and GMS data as input to NWP models on an operational basis.

5.2 The operational system will be upgraded to cater to growing user requirements, such as increased storage capacity, etc.

PART VI VALIDATION AND VERIFICATION OF SATELLITE DATA AND DERIVED PRODUCTS IN OPERATION INCLUDING PERFORMANCE STATISTICS

6. This will be carried out later.

PART VII CONTACT

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SWEDEN

Swedish Meteorological and Hydrological Institute, SMHI

Part I Summary of the major highlights of research applications and operational changes.

1.1 SMHI is still using PROSAT (Processing System for Meteorological Satellite Data) for the reception, processing, archiving and presentation of satellite data from the polar orbitting NOAA satellites and the European geostationary satellite Meteosat. The system is used in the daily operations but also as an important tool for research and development.

1.2 PROSAT was at the end of 1991 used for processing and presentation of ERS-1 SAR data.

1.3 The system is regularly producing a number of operational products and cloud classification based on all channels from the AVHRR of the NOAA-satellites. The products are used at main office and also communicated to remote civil and military forecast offices responsible for nowcasting and Very Short Range Forecasting where they are extensively used.

NOAA images are used in the operational work in combination with METEOSAT images with higher temporal resolution. Satellite images are displayed on screens together with radar composites and fields from analyses or forecasts of NWP models but hardcopies are also available.

1.4 Satellite images (NOAA-AVHRR) have been used in hydrological projects in recent years. The images have been used to calculate snow cover and lake areas. Real-time snow cover information has then been used along with hydrological models to forecast river runoff. The products have been delivered to regional hydropower energy regulation groups in Sweden.

1.5 The use of AVHRR data for sea ice and sea surface temperature mapping is operational at SMHI, however, the cloud cover is extensive during the winter period and limits in practice the amount of usable images. Hence, a long term programme is running to prepare the use of SAR data from the ERS-1 satellite launched in 1991. SMHI is involved in the calibration/validation and demonstration programme of this satellite under the PIPOR (Programme for International Polar Ocean Research) programme. The winter 91/92 ERS-1 SAR images were transmitted in almost real-time to SMHI from the ESA station in Fucino. Data were geometrically calibrated to Mercator whereafter sub-images were sent to two icebreakers in the northern part of the Baltic Sea using the NMT (Nordic Mobile Telephone net). The digital images were presented on Mac-mashines within 24 hours to the crew and scientists for validation. Locations on the sea ice were performed using battery-driven GPS navigators. In this way the features on the images could be found in nature for detailed investigations.

1.6 In the Baltic Sea blue-green algae can bloom extensively during warm and calm weather conditions in the summer time. These are detectable in NOAA-AVHRR images in the visible channels. When critical conditions prevail the evolution of the bloom both in time and space is followed using the images. Images are archived automatically after special conditions on satellite height and cloudiness are fullfilled.

Part II Major research and development in the applications of satellite data, derived products and services

Meteorology

2.1 The major research activities have been devoted to the automatic multispectral classification of NOAA/AVHRR data. The activities have been reported by Karlsson 1989 and 1990 and Liljas 1988, 1989 and 1990. A detailed description of the model can be found in Karlsson and Liljas, 1990.

2.2 METEOSAT data has been used in studies of rainfall. NOAA/AVHRR precipitation fields have been used as ground truth. METEOSAT vis and IR data has been combined to give the amount and pattern of rainfall over 12 hours.

2.3 TOVS processing is not performed operationally. However, an evaluation of TOVS products have been performed over one year. Forecasts from the SMHI Limited Area Model (+6) have been used as initial guess. The TOVS retrievals have been compared with radiosonde profiles and it was found that the RMS differences were small compared with similar studies (Liljas and Svensson,1991).

2.4 Work is now focused on developing methods to utilize the derived cloud information in objective analysis schemes (Karlsson 1991, 1992).

Hydrology and Oceanography (incl Sea Ice)

2.5 Short term enviromental monitoring studies has been undertaken in the northern Baltic during an intensive interdisciplinary study - The Gulf of Bothnia Year 1991. The reasearch programme is a cooperative work together with Canada Center of Inland Waters and Finnish Institute of Marine Research. Within the remote sensing part a time series of AVHRR images covering one year has been gathered. Sea surface temperature and suspended matter are used as tracers for water masses. Tests to obtain drift velocities are made, using concecutive satellite images. Also sea surface drifters are used for dispersion and circulation studies together with the AVHRR images. The drifters position are transmitted via the ARGOS system.

2.6 Considerable efforts are put on the preparations for the ERS-1 satellite, with emphasize on sea ice applications of the synthetic aperture radar (SAR). The SAR is not limited by clouds such as visible and thermal sensors, which make the SAR sensor of great value in hostile areas such as the Arctic and the Baltic Sea during winter time. In 1988 an international field programme was undertaken involving the Canada Center of Remote Sensing airborne SAR. A dedicated ground observation programme made it possible to study the SAR response on various sea ice features and internal physical structure.The developments from this field experiment are used to obtain an optimal geophysical calibration and validation experiment for the ERS-1, which was undertaken in February and March 1992 in the Baltic Sea. ERS-1 SAR data were also used for navigational and research activities during the high Arctic interdisciplinary expedition with the Swedish icebreaker Oden in August to November 1991. These research programmes involved studies of SAR images during melting conditions as well as during cold weather conditions. The aim is to find classification schemes for ice types such as open water, thin ice, level ice and ridged ice, especially in first year sea ice.

PART IV System for satellite applications in operational use.

Description of PROSAT

4.1 SMHI installed PROSAT (PROcessing system for meteorological SATellite data) in 1987. The main contractor for the system was Ericsson Radar Electronics AB. The company delivered the system with TERAGON-CONTEXT AB as the main subcontractor. PROSAT can be partitioned in three main parts:

* Host computer.
* Satellite data reception system.
* Image processing system with workstations.

4.2 The system is further described in Karlsson and Liljas 1990. It has automatic scheduling and reception of digital data from the METEOSAT and NOAA satellites. Images are produced according to operational requirements, stored on a special videodisc and presented on standard geographical areas in near real time for meteorological forecasters at different locations and for hydrologists and oceanographers. The system has capability to allow both operational use and research. At the central office of SMHI there are four main workstations. PROSAT is providing fast processing of multispectral satellite data. A system for real time processing of TOVS data is also included (See Svensson,1989).

Operational products, meteorology

4.3 An operational cloud classification based on all channels from the AVHRR of the NOAA-satellites was implemented in 1989. The classified images are used extensively at the remote civil and military forecast offices responsible for nowcasting and Very Short Range Forecasting.

NOAA images are used in operational work in combination with METEOSAT images with higher temporal resolution. Satellite images are displayed together with radar composites and fields from analyses or forecasts of NWP models.

Operational products, hydrology and oceanography

4.4 The hydrological operational applications has been focused on real-time snow cover in Swedish montain areas. The snow mapping is used to increase the quality of runoff forecasts. The image products classifies, snow cover, open water and clouds in the drainage area, using NOAA-AVRR images recieved at SMHI.

4.5 Data from one remotely placed hydrological station is transmitting information using the ARGOS system.

4.6 Sea ice mapping as well as sea surface temperature using AVHRR images as input is operational at SMHI. The products are used for icebreaking activites and shipping. Image products are transmitted to the icebreakers in the Baltic, using the Nordic Mobile Telephone net. The product is a merged single layer image obtained from an RGB-image in Mercator projection. Onboard dedicated software is used to present the products and to plot ship tracks etc.

4.7 Sea surface temperature is mapped weekly at SMHI. To extend the information from coastal stations and ships in the area images from AVHRR are used. These are presented to the operator in digital form, showing the radiation temperature in Mercator projection with an option to calculate the absolute bulk temperatures. During summer these products also contain the red visible channel in full radiometric resolution for mapping of algal blooms mainly in the Baltic Proper.

Archiving facility

4.8 A limited, but fully automatically archiving facility of NOAA-AVHRR products for marine applications are in operational use since June 1992. The size of the images are 1024*1024 pixels (= km) and cover channels 1,4 and 5 in full geometric and radiometric resolution (8-bit data) in Mercator projection. The three archiving criteria are a satellite height of at least 50 ° above horizon, a cloudiness of less than 20 % in one out of 4 subareas of the image and received during 11^{45}- 14^{00}UTZ (to gain a sun zenith angle of at least 30°). These criteria will certify that the stored images are of high quality and useful for marine applications. The covered area is the Baltic Proper, Kattegatt and the Skagerrak (i.e. eastern part of the North Sea).

Part V Plans for future operational systems for satellite applications to meteorology, oceanography and operational hydrology

5.1 PROSAT

The system will continue to be the basic system for satellite applications in meteorology, hydrology and oceanography for the following years. Discussions have, however, started of an adaption to up-to-date hardware technique.

5.2 ERS SAR images

Plans are under development to at least semi-operationally obtain ERS-1 and -2 SAR images at SMHI for sea ice services. The institute is also interested in the posibility to receive images from SeaWiFS onboard the Sea Star satellite for ocean color applications.

Part VI Validation and verification of satellite data and derived products used in operations, including performance statistics.

Validation and verification.

6.1 A verification system for the multispectral classification scheme has been developed. The operational verification started in 1991. Comparison with hourly cloud observations at synoptic weather stations have shown RMS errors in the range of 2 - 3 octas and mean errors near -1 octa for the total fractional cloud cover. Best agreement has been found for high satellite elevations. Problems are encountered at sunrise and sunset in combination with low satellite elevation.

Part VII Other items (references, publications and names of scientists in charge, etc.)

7.1 Staff

Bertil Håkansson	Oceanographic applic. and Argos buoys
Karl-Göran Karlsson	Meteorological applications
Erik Liljas	Meteorological applications
Mats Moberg	Hydrological applications
Sten Orrhagen	System Hardware and Software
Gunnar Pettersson	System Hardware and Software
Jan Svensson	TOVS retrievals
Thomas Thompson	ERS-1 preparations, Sea ice remote sensing

7.2 References

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THAILAND

PART I Summary of the major highlights of research applications and operational changes

1.1 Since 1989, the Meteorological Department installed the new equipment to acquire the AVHRR (Advance Very High Resolution Radiometer) data from the American polar orbiting satellite, NOAA-11 and NOAA-12, also the S-VISSR (Stretched Visible and Infrared Spin Scan Radiometer) from the Japanese geostationary satellite, GMS-4 on every 6 hour and hourly basis respectively.

The meteorological satellite data are mainly used for daily weather forecasting, aviation and warning activities. Furthermore, the NOAA AVHRR data are used in conducting crop and flood monitoring.

The NOAA and GMS images not only support the activities of the Meteorological Department, but also the following products are very helpful:

- Sea surface temperature;
- Tovs data;
- Typhoon tracking and forecasting;
- Cloud tracking;
- Satellite cloud wind;
- Colour images.

UNITED KINGDOM

Meteorological Office

PART I Summary of the major highlights of research applications and operational changes

1.1 Imagery from AVHRR, Meteosat and SSM/I has been collected, processed and distributed in support of the Global Precipitation Climatology Project's 2nd Algorithm Intercomparison Project.

1.2 Meteosat imagery is used in conjunction with a ground-based precipitation radar network to diagnose likely areas of rain beyond the range of radar coverage, and to estimate cloud-cover and cloud-top height.

1.3 Data from three instruments recently launched on ERS-1 are being assessed for their operational value.

1.4 The Microwave Airborne Radiometer Scanning System, installed on the C-130 aircraft of the Meteorological Research Flight, has been used to investigate the properties of sea-ice, snow and sea surfaces and emission from water vapour. These observations are being used to develop a radiative transfer model for future satellite sounding instruments.

PART II Major research and development in the applications of satellite data, derived products and services

2.1 Imagery from AVHRR, Meteosat and SSM/I covering the UK and part of Europe has been collected and processed in support of the Global Precipitation Climatology Project's 2nd Algorithm Intercomparison Project. These data have been distributed to participating scientists from 21 groups to test methods of determining rainfall from satellite imagery. A EUMETSAT fellowship currently supports a research scientist working in this area. (R Allam)

2.2 The precipitation nowcasting system (called FRONTIERS) uses Meteosat visible and infra-red data to diagnose areas of precipitation outside the area covered by the UK Weather Radar Network. A preliminary investigation of the use of smoothed Meteosat water vapour data suggested that, when combined with conventional infra-red data, delineation of precipitation areas was more skilful than using infra-red alone. (R Brown).

2.3 It is now well known that for convective precipitation there is a high degree of correlation between area-average rainfall and the fraction of an area covered by rainfall in excess of a pre-defined rate. An investigation using winter-time frontal precipitation has produced similar results indicating that the application of the method to produce precipitation accumulations from a satellite may be more general than previously thought. (R Brown)

2.4 Data from the Stratospheric Sounding Unit (SSU) are processed routinely to derive daily synoptic maps of radiance, thickness and geopotential heights at selected pressure levels in the stratosphere up to 1 mb (100 Pa). They are used for internal research and have been made available to overseas research collaborators and international campaigns. A copy of the quality-controlled archive of these data, spanning 1978 to the present, has been deposited with the Geophysical Data Facility at the Rutherford Appleton Laboratory (RAL). (A O'Neill)

2.5 The first European Resources Satellite (ERS-1) was launched into polar orbit on 17 July. It contains three instruments of particular meteorological importance: a wind scatterometer, a radar altimeter and an Along-Track Scanning Radiometer (ATSR). From these instruments measurements of surface wind, wave height and sea surface temperature, respectively, can be determined. Work on deriving winds has, in close collaboration with ESA, mainly concentrated on optimising the algorithms that convert engineering units to physical parameters. Comparisons with wind analyses have been very encouraging, indicating results which are of a higher quality than those currently obtained from ships. An early comparison of wave data with model output was sent to ESA, and in common with results from other wave-modelling centres, convinced ESA of a processing error which was quickly corrected. Sea surface temperatures have been analysed as part of the routine SST analyses. During the period all satellite SST have been greatly affected by the eruption of Mount Pinatubo. (D Offiler, S Foreman and C Hall).

2.6 Work was started on a further contract from EUMETSAT to study the semi-transparency correction used to assign the altitude of the retrieved cloud-track winds. (R Lunnon)

2.7 The Meteorological Office has a major role in exploiting data from the NASA UARS satellite, launched in September 1991, through the assimilation of meteorological and chemical data from UARS into a sophisticated general circulation model of the troposphere and stratosphere. The aim is to produce analysed fields of optimal quality, which incorporate measurements form several instruments, and which are internally consistent. The fields will be used for internal research, and made available to members of the UARS science team for collaborative research. Substantial progress has already been made: trial assimilations using NOAA operational data have been made and a large suite of data-handling and diagnostic programs has been written. (A O'Neill)

PART III Techniques development and applications of satellite data, derived products and services

3.1 A programme of research and development is in place to ensure that new requirements for imagery products are satisfied. (R Allam)

3.2 Work has continued on the 500-page reference manual containing guidance for operational meteorological forecasters on interpreting satellite and radar images. It will contain important guidelines, which have recently been established as a result of the improved quality and frequency of images and the results of the latest research. The project is sponsored by EUMETSAT, NOAA/NESDIS and WMO, and many organisations from Europe and North America have contributed to the work. It is being edited by staff at the Meteorological Office and Penn State University. (M Bader)

3.3 Object-oriented programming techniques are being used to relate a simple, physically-based conceptual model of thunderstorm development to radar and satellite observations in order to produce analyses and very short range forecasts. The system attempts to deduce the stage of development of a convective cell by calculating how a cell at that stage and location would appear to the (imperfect) observing systems, and then matching that to the actual observations. Meteosat IR data are useful in helping to resolve uncertainties in identifications based on radar data alone, in spite of their relatively poor resolution. (B Conway)

3.4 Development of the system NAME (Nuclear Accident Modelling Exercise), which produces hourly analyses of rainfall amount and distribution at a horizontal resolution of about 5km over the COST-73 area of NW Europe has been completed and it has been handed over for operational use. The analyses, which are available within 2 hours of observation time and are stored in a continuous 10-day rolling archive, incorporate quality-controlled data from FRONTIERS, as well as European radar data, Meteosat imagery and NWP forecast products. They are for use in conjunction with a dispersion and deposition model to estimate patterns of contamination in the event of a nuclear or large-scale chemical accident. Provision has been made to extend the area of coverage with the planned expansion of the COST-73 area. (B Conway)

3.5 The Local Area Soundings System (LASS) was in operational use throughout the period. The system receives raw sounding data directly from NOAA polar orbiting satellites via the ground station at Lasham when they are in line-of-sight, giving coverage over much of Europe and the North Atlantic. LASS processes these radiances in conjunction with background data from a regional numerical forecast model to provide temperature and humidity profiles at approximately 120 km spacing. This information is used by central forecasting operations, both in chart form to aid subjective analyses and objectively in data assimilation. During this period the processing has been redesigned to permit the use of more accurate background data and quality control criteria have been tightened. An alternative method in which cloud information is also retrieved has been tested. Work has started on the development of a Global Soundings System (GLOSS) based on radiance data received from NESDIS in Washington. (A J Gadd)

3.6 The Microwave Airborne Radiometer Scanning System (MARSS) comprising two AMSU-B microwave channels was installed on the C-130 aircraft of the Meteorological Research Flight. This has been used to investigate the properties of sea-ice, snow and sea surfaces and emission from water vapour. These observations are being used to develop a radiative transfer model which will be at the heart of the retrieval scheme for this new generation of sounding instruments. (J Foot)

PART IV System for satellite applications in current operational use

4.1 A dedicated computer system called Autosat-2 captures, via the ground station at Lasham, high resolution imagery from both the Advanced Very High Resolution Radiometer (AVHRR) on NOAA polar orbiting satellites and the two Meteosat geostationary satellites, and generates a wide range of digital imagery products for forecasters and media customers. (R Allam)

4.2 The existing precipitation nowcasting system, FRONTIERS, and the local area sounding system, LASS, both discussed earlier in this report, will continue to be used operationally.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 The programme to provide a series of flights of the 3-channel Stratospheric Sounding Unit (SSU) continues. Two SSUs are required to fly on NOAA-I and NOAA-J in 1992 and 1993 respectively. They will provide stratospheric observations through to about 1994 allowing overlap with NOAA-K and supporting the Upper Atmosphere Research Satellite (UARS) mission. SSU-F7 is integrated onto NOAA-I having successfully undergone all Thermal Vacuum testing and now awaits launch in February 1992. The final SSU has been produced by refurbishing the engineering model D3. This model had to have major rework following failure of a development pressure modulator but has now been repaired with all functional testing and recalibration complete. It is undergoing final checks before integration to NOAA-J. The option of accepting a reduced specification will be considered following these checks. (B Greener)

5.2 The next generation of NOAA polar orbiting operational meteorology satellites will carry the Advanced Microwave Sounding Unit (AMSU). There are two components, AMSU-A (for temperature profiles), which is to be provided by the USA, AMSU-B (for tropospheric humidity profiles), provided by the Met. Office. AMSU-B has a spatial resolution three times higher than that of AMSU-A, which will assist the retrieval process in handling cloudy regions. The project to provide three flight models is on schedule with acceptance tests of the Engineering Model in progress by the end of 1991. A calibration and test facility within the Defence Research Agency Space Simulation Centre has been completed. (B Greener)

5.3 The Along Track Scanning Radiometer (ATSR), launched on ERS-1, is a sensitive infra-red radiometer of unprecedented accuracy for measurement of sea surface temperature. The Meteorological Office has designed, built and tested the focal plane assembly, the heart of the instrument and provided the high accuracy external targets for its calibration prior to flight. The flight spare focal plane assembly was completed at the beginning of the year and this is now being used in the follow-on programme, ATSR-2. Limited consultancy work is being provided to RAL and to the Australian company who are manufacturing and testing the second assembly for ATSR-2. The follow-on instrument will have additional solar channels, which are being designed and built by RAL. (R W Saunders)

5.4 A contract for ESA was undertaken to study the use of data from future Doppler wind lidar (DWL) instruments. Three main headings were considered: assimilation and quality control, data representativeness errors and case studies of data utility. Recommendations on the production of simulated DWL observations for further studies were given. (A Lorenc)

5.5 Over the next few years, the precipitation nowcasting system, FRONTIERS, is to be developed into a fully automated system and integrated into the mesoscale forecasting model. (R Brown)

5.6 A study programme continues to assess the balance between cost and benefit in the space sensing field and to identify those space programmes that appear to have the greatest potential for meteorological and climate users. In particular the following studies have been undertaken or are in progress:

(a) requirements for 'operational' climate instrumentation in the context of the Global Climate Observing System (GCOS), where long-term continuity and consistency are of particular importance;

(b) the requirement for a Climate Data Centre to provide high level data sets of analysed climate parameters, making optimum use of space and conventional observations.

(c) optimisation of planned instruments, including AMSU (future generations), ATSR, the Multifrequency Imaging Microwave Radiometer (MIMR), advanced sounders and the high-resolution SEVIRI (Spinning Enhanced Visible Infra Red Imager) on Meteosat Second Generation(MSG);

(d) the concept of Doppler lidar detection of wind profiles, the representativeness of such data and methods of quality control and assimilation;

(e) active instruments for measuring parameters such as precipitation or cloud in three dimensions, initially in the context of the GEWEX (Global Energy and Water-cycle Experiment) initiative and eventually for GCOS. (P D Curtis)

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

6.1 Three validation campaigns were successfully undertaken in the latter part of 1991 after the launch of ERS-1 using the C-130 aircraft of the Meteorological Research Flight. Two were off the Norwegian coast and were carried out for ESA; the aircraft provided in near real time in-situ observations of wind to validate products from the scatterometer on ERS-1. The other campaign was based at Ascension Island and used a radiometer with similar channels to those on ATSR. Apart from obtaining validation data for ATSR other measurements were taken to characterise the radiative properties of the volcanic dust which was affecting the retrieval of sea surface temperature in the tropics at the time. (D Offiler and R Saunders)

6.2 Validation of ERS-1 products is also being accomplished through comparison with forecast models, as mentioned in Part II.

6.3 A one-year trial of FRONTIERS precipitation forecasts, undertaken by the National Rivers Authority and the Meteorological Office, has been evaluated and a report published. Results were encouraging but the trial has been extended because of a lack of significant rainfall during the year. (R Brown)

PART VII Other items

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ACRONYMS

AIP	Algorithm Intercomparison Project
AMSU	Advanced Microwave Sounding Unit
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
CAS	Commission for Atmospheric Sciences
COST	Committee for European Cooperation on Science and Technology
DWL	Doppler Wind Lidar
ERS-1	First Earth Resources Satellite
ESA	European Space Agency
EUMETSAT	European organisation for the exploitation of Meteorological Satellites
FRONTIERS	Forecasting Rain Optimised using New Techniques of Interactively Enhanced Radar and Satellite Data
GCOS	Global Climate Observing System
GEWEX	Global Energy and Water-cycle Experiment
GLOSS	Global Soundings System
IEEE	Institute for Electronics and Electrical Engineering
IR	Infra Red
LASS	Local Area Soundings System
MARSS	Microwave Airborne Radiometer Scanning System
MIMR	Multifrequency Imaging Microwave Radiometer
MSG	Meteosat Second Generation
NAME	Nuclear Accident Modelling Exercise
NASA	National Aeronautics and Space Administration
NESDIS	National Environmental Satellite Data and Information Service
NOAA	National Oceanic and Atmospheric Administration
NRA	National Rivers Authority
NWP	Numerical Weather Prediction
RAL	Rutherford Appleton Laboratory
SEVIRI	Spinning Extended Visible Infra Red Imager
SSM/I	Special Sensor Microwave Imager
SST	Sea Surface Temperature
SSU	Stratospheric Sounding Unit
UARS	Upper Atmosphere Research Satellite
USA	United States of America
WMO	World Meteorological Organization

UNITED STATES OF AMERICA

PART I Summary of major highlights of research applications and operational changes

MOUNT PINATUBO VOLCANIC ERUPTION (Matson)

During the eruptions of Mt. Pinatubo in June 1991, NESDIS provided information to the scientific and aviation community about the altitude and spatial distribution of the subsequent ash clouds. At the request of the U.S. Department of Defence (DOD), the NOAA/Federal Aviation Administration (FAA) Volcanic Hazards Alert Plan was put into effect, even though the ash cloud was not impinging on U.S. airspace, a usual criterion for implementing the plan. As part of the plan, NESDIS scientists obtained and examined all satellite imagery from NOAA polar-orbiting satellites and from the Japanese Geostationary Meteorological Satellite (GMS) to determine plume altitudes and ash cloud movement. Ash drift trajectories were plotted based on NOAA trajectory models. This information was reported to the FAA every six hours for dissemination to aviation interests. The NESDIS Aerosol Optical Thickness product produced from visible AVHRR imagery was used to globally monitor the distribution and spread of the volcanic stratospheric ash cloud that eventually covered the Earth.

STRATOSPHERIC CONSTITUENTS (Planet, Bowman)

A team, consisting of Government and academic scientists was established to review, on a regular basis, the existing products derived from the Operational Solar Backscatter Ultraviolet instruments (SBUV/2) on the NOAA satellites. The initial meeting was held in April 1992. A report has been submitted with their observations and recommendations. Efforts to comply with the recommendations pertinent to NOAA have begun. These include improving user access to NESDIS ozone products, and continuing overlap of orbiting SBUV/2 instruments.

An International Dobson Data Workshop was held in September 1991 sponsored by the NOAA climate and Global Change Program. As the historical record of the Dobson total ozone data series is of importance as a source for evaluating ozone trends and also for comparisons with satellite observations, it becomes imperative that the stability and continuity of the data set be well understand.

As several stations in the international Dobson network have had their data reanalyzed and improved, it is reasonable to accomplish the same for other stations. The participants addressed three topics; (1) could the precision of the data from other stations be improved in a similar fashion; (2) What procedures should be employed in this reanalysis; (3) which stations should be reanalyzed first.

Results of the Workshop are published in "International Dobson Data Workshop Summary Report", R.D. Hudson and Walter G. Planet, NOAA Technical Report NESDIS 60, Washington, D.C. (February 1962).

Improvements to the algorithm used to calculate total ozone amount from the NOAA SBUV/2 systems have been implemented into the operational data processing. These improvements will provide more realistic observations especially in the polar regions in support observations of the Antarctic ozone hole.

Observations of the 1991 Antarctic ozone hole were made by observations of the NOAA Tiros Operational Vertical Sounder (TOVS). Results were generally consistent with those obtained by other measurement systems. Weekly contributions were made by NESDIS to be included in the WMO reports on the ozone hole.

SEA SURFACE TEMPERATURES (Sapper)

Observations of sea surface temperature at 8 kilometer resolution continued to be produced from NOAA-11 infrared data during 1991 and transmitted to the National Meteorological Center of the National Weather Service, the Navy Fleet Numerical Oceanography Center, and the World Meteorological Organization (WMO) for use in oceanographic and meteorological models and products. These observations are used to produce a 100 kilometer global resolution chart and 50 kilometer and 14 kilometer regional resolution charts. The National Climatic Data Center archives the majority of these products.

WMO receives SST observations which are sent out over the Global Telecommunications System (GTS). The current algorithm which collects an SST temperature for a particular gridpoint or grid box, merely takes the nearest observation to that gridpoint from an 8-day rotating file of observations. A work order has been issued to change this scheme to an 8-day averaging method for the grid box.

Mapped sea surface temperature images at 1.1 kilometer resolution at nadir are being produced operationally from NOAA-11 LAC and HRPTinfrared data. All the operational mapped areas are in U. S. Coastal(OPC) waters. These images are being sent to the Ocean Products Center and the National Oceanographic Data Center (NODC) for near real-time and retrospective distribution to regional coastal usersthrough NOAA's CoastWatch program.

RADIATION BUDGET (Sapper)
Global measurements of daytime and nighttime outgoing longwave flux and incoming available and absorbed solar radiation continue to be produced from NOAA-10/11 infrared data. Implementation of the new NOAA K,L,M era Radiation Budget Orbital Processing Program complete with new algorithms and new derived parameters is planned for next year. Outgoing Longwave Radiation (OLR) fluxes from HIRS and the co-location of GAC targets with HIRS spots are among some of the new derived parameters and new algorithms.

AEROSOL (Sapper)
Production of operational aerosol data continued in 1991. The following is a list of aerosol products currently being archived:

1. Aerosol Weekly 100 km Analyzed Field File - a one degree resolution file containing specific information pertaining to global latitude and longitude intersections, i.e., optical thickness, gradients, number of observations used for analysis, etc.

2. Aerosol Daily Summary Table - contains statistical information pertaining to aerosol observations in each (10 x 10) degree Latitude/Longitude box.

3. Aerosol Monthly Mean Field File - a gridded file of optical thicknesses and other information. The optical thickness at each gridpoint is the average of optical thicknesses calculated for each week within the month at that gridpoint.

4. Extreme Events Aerosol Observation File - this file contains 37 days of aerosol observations of optical thicknesses which are above a threshold of 0.2.

FUTURE PLANS - There are plans to implement the aerosol correction factor for Sea Surface Temperatures. However, it is presently in the research stage of development.

WINDS (Hughes)
Migration of the picture-pair low-level cloud motion winds system from the NOAA Central Computer Facility to the NESDIS Central Environmental Satellite Computer System (CEMSCS) has begun. Parallel production is scheduled to begin in October 1992.

IMAGES (Shellman)
In support of the NWS AWIPS-90 project, the final version of GOES-7 remapping system was implemented. A 15 degree by 20 degree sector centered over Liberal, Kansas and a Northern Hemisphere sector are produced every thirty minutes. These remapped half-hourly 1-Km visible, 4-Km infrared and 8-Km water vapor products are transmitted to the NWS in Boulder, Colorado and Norman, Oklahoma in near real-time.

Participation in the development of the No-GOES contingency plan continues. New and enhanced NOAA Polar Orbiter and Defense Meteorological Satellite Program products are provided for evaluation by the users as replacement products in the event of a No-GOES situation.

PART II Major research and development and applications of satellite data, derived products and services

INTERNATIONAL SATELLITE CLOUD CLIMATOLOGY PROJECT (ISCCP) (Kidwell)

Eight years of data of the twelve year collection period (July 1983-June 1995) have been accumulated for this project. NOAA/NESDIS contributes Level B2 data for both operational polar orbiters (NOAA-11 and NOAA-12), as well as correlative data, including NMC surface observations, TOVS Sounding Product, GOES orbit and attitude data, snow cover, and sea ice analyses. The first eight years of Stage B3 data (through June 1991) have been processed and are archived at the ISCCP Central Archive (which is NESDIS' Satellite Data Services Division).

ISCCP's Global Processing Center (NASA/GISS) has completed generating the Stage C1/C2 data through December 1990. Stage C data are cloud parameters obtained from B3 data and correlative data using an experimental cloud algorithm. All C data are computed for a standard equal-area grid with approximately 250 km spatial resolution. Stage C1 data have three hourly time resolution while C2 data are monthly averages of the C1 data. These data are currently available from SDSD for the period July 1983 through December 1990.

NOAA SATELLITE OBSERVATIONS OF AEROSOL OPTICAL THICKNESS OVER OCEANS (Stowe, Pellegrino, McClain)

In connection with the operational derivation of aerosol optical thickness (AOT) from AVHRR data over the oceans, an effort was made to match Soviet ship sunphotometer data with the AVHRR aerosol data records. Based on this work, an abstract was prepared for the IAMAP '91 symposium on the comparison of Soviet ship (the Akademik Vernadsky research vessel) and NOAA/AVHRR satellite aerosol optical thickness measurements. Help was provided by the NESDIS International Affairs office for the arrangement of a visit by a Soviet scientist from the Marine Hydrophysics Institute, Sevastopol, in relation to the comparisons. Graphs were prepared on the comparisons for the IAMAP meetings in August. These showed that satellite AOT values were systematically lower than sunphotometer values.

Dr. Larry Stowe became a participant on the NOAA Chief Scientist's team monitoring the evolution of aerosol clouds from the eruption of the Mt. Pinatubo volcano. Effects of the eruption on the AVHRR AOT product were documented, and the westward transport of the stratospheric aerosol layer was tracked along the equator. Following a press release, the Washington Post gave front-page coverage of the before and after images of the AOT product. Dr. Stowe was interviewed on the ABC Nightline show and the Discovery Channel. The CBS Evening News showed a video of a 9-week sequence of AOT maps of the Mt. Pinatubo aerosol layer. A manuscript on the satellite measurements was submitted for publication in a special issue of Geophysical Research Letters. A 12-week composite image was published in the NOAA/CAC Climate Diagnostic Bulletin for September. Continued regular monitoring has shown the thinning of the tropical band of Mt. Pinatubo aerosols, while the Mt. Hudson/Mt. Pinatubo aerosol layer in the 40S - 60S latitude band continued to thicken. Effects of the volcanic aerosol layers on sea surface temperature (SST) retrievals have been analyzed and documented.

REMOTE SENSING OF CLOUD PARAMETERS WITH NOAA SATELLITE DATA (Stowe)

The code from the Clouds from AVHRR (CLAVR) project was restructured to process either GAC or LAC images from the same program. Adjustments have been made to that part of the CLAVR algorithm dealing with non-linear corrections that must be applied to the brightness temperatures for AVHRR channels 4 and 5. Other changes included a reduction in the maximum solar zenith angle allowed for daytime calculations (for swaths containing the terminator). This helps to eliminate discontinuities in analyzed global cloudiness at the transition between day and night algorithms. Prior to implementation into a real-time processing system, these and other revisions were reapplied in the production of global maps for a summer and a winter day. Color displays of the global maps for the two test days (July 9, 1986 and February 9, 1990) look very good, but suggest residual problems in the polar regions. A complete set of 1B (1B data with cloud flags), 1CD (cloud/radiance data), and CAD (cloud analysis data) data sets for the two days have been prepared for distribution. Finally, the development of modifications to the Cloud Analysis Mapper (CAM) program was initiated for the generation of Clear Radiation Data Sets over a global grid, a Phase II part of CLAVR.

A meeting was held with Dr. James Coakley (and 6 associates) from Oregon State University during which the Coakley group demonstrated their capabilities for analyzing AVHRR cloud data with the Spatial Coherence technique. Cloud clearing algorithms were discussed in a meeting with the NAVY (NOARL); it was decided to intercompare algorithms with local area coverage (LAC) scenes from the CLAVR project.

SATELLITE EARTH RADIATION BUDGET STUDIES (Jacobowitz)

The Earth radiation budget is currently derived from the Advanced Very High Resolution Radiometer (AVHRR) observations on the NOAA polar-orbiting satellites. Models for estimating the broadband albedos and fluxes from the narrowband channels will soon be dependent upon the scene type (underlying surface type and cloud amount). A new software system for deriving the radiation budget products was compared with the older system using the same input data. Differences were primarily within the acceptance criteria. The new system will become operational shortly. The new system will also generate a more accurate outgoing longwave radiation (OLR) flux from the High Resolution Infrared Sounder (HIRS) in addition to that obtained from the AVHRR.

A study of the effects of the Kuwaiti oil fires was made by collecting a special radiation budget data set for an extended region surrounding Kuwait. Time series analysis of the albedo for selected regions showed substantial decreases immediately following the onset of the fires (February) and a recovery to normal levels about the time the fires were put out later in the year. A shorter but similar data set was collected to study the effects of the Mt. Pinatubo volcano. A sharp minimum in the OLR flux below 90 W/m2 occurred the day of the cataclysmic explosion. The maximum in the albedo occurred the day after.

EXPERIMENTAL SSM/I PRODUCTS (Pichel/Taylor)

Environmental products from the DMSP SSM/I are being generated to test algorithms, gain experience with microwave product production, and allow the National Meteorological Center and the Navy/NOAA Joint Ice Center to assess the utility of microwave products. Products currently being tested are precipitation rate over ocean and land, wind speed and total precipitable water over ocean, sea ice, and snow cover.

PART III Description of technique development and applications of satellite data, derived products and services

NOAA K,L,M POLAR TEMPERATURE/MOISTURE PROFILES (Drahos)

Work on implementation of System '90 or RTOVS (Revised TOVS) operational sounding system is nearing completion. The RTOVS system will continue to produce the current sounding suite of products and retain the current TOVS product resolution (grid spacing) and minimum variance/simultaneous physical retrieval science. Science upgrades include a radiance classification first guess technique, utilization of the AVHRR/GAC for improved cloud clearing, and enhanced quality control for the system and products (based upon forecast comparison). The system is to be implemented in late 1992 and there should be some slight product improvement, but no format or data volume impact upon the user. Work on the science/system definition for System '92 or ATOVS (Advanced TOVS) has also continued. This system is to be installed when NOAA-K is launched (after the beginning of 1995). The product resolution (grid spacing) is defined to be that of the AMSU-A, however, this will be obtained by collocating AMSU to the HIRS location. Improvements include use of very high speed computers to incorporate better physics, more accurate products because of the AMSU instrument, and utilization of the NMC 6-hour forecast for quality control and a choice for the retrieval first guess based upon either the radiance classification or NMC-6 hour forecast, whichever is better. Distribution and archive of the NOAA-K/AMSU products will require major revision to the distribution systems. Planning for these changes in addition to new calibration procedures are under way.

TIROS OPERATIONAL VERTICAL SOUNDER (TOVS) (Chalfant)

Currently, TOVS operational sounding products are being derived from data acquired from NOAA-11 and 12 polar orbiting satellites. These satellites are scheduled to be replaced be NOAA-I and NOAA-J in May 1993 and December 1993 respectively. Several science improvements have been implemented into the TOVS operation over the last year which affect the reliability and accuracy of the sounding (or related) products. These included the implementation of a new physical retrieval technique for the derivation of total ozone in partially cloudy regions from the HIRS/2 instrument, procedures to improve cloudy sounding accuracy, and procedures to improve the quality and meteorological representation of the radiosonde/retrieval data used for the tuning of the TOVS sounding products. In addition, interactive image/graphics systems have been implemented for throughput and quality monitoring of the sounding products and are used for the evaluation of proposed science improvements prior to their implementation in the operation. Work is continuing in the development of improved quality control procedures using NMC forecast data and radiometric data to improve the first guess used for the retrieval process.

PHYSICAL RETRIEVAL SYSTEM (Burdsall)

The physical retrieval system has been in the TOVS processing since September 1988. The physical retrieval system has proven itself as a reliable system with several advantages over the statistical regression system previously used in TOVS. Physical retrieval has shown improvements in regions of changing weather because it can respond to changes in the weather more quickly than the regression system. Another advantage is the physical retrieval system allows a new satellite to be implemented more quickly than the regression system. Overall, the physical retrieval system is less radiosonde dependent and hence less time is needed to get an acceptable distribution of radiosondes.

INTERACTIVE RETRIEVAL SYSTEM

An interactive retrieval system is one in which the data assimilation and forecast functions of a NWP system are linked directly with the satellite temperature/moisture retrieval system. In particular, the six-hour forecast is used as the initial guess in the retrieval system, the retrieved profiles are assimilated by the NWP analysis system, a new six-hour forecast is made, which in turn is used as the initial guess of the retrieval system, and a closed cycle is continued in this manner.

An impact study of the system was conducted for the period of September 28 through October 30, 1991. The parallel tests using the NMC global data assimilation system indicate little difference can be expected in the medium-range (5 day) forecast skill in the Northern Hemisphere compared to the obtained with the current operational retrievals. However, in the Southern Hemisphere a significant improvement in short to medium-range forecast skill may be expected with the interaction retrievals. Using a short-range forecast of a general circulation model as the first guess for the satellite retrievals represents a significant step forward in our ability to optimize the use of satellite data for numerical weather prediction.

GOES-I/M SOUNDINGS AND WINDS (Gray)

Development and implementation activities in support of the operational GOES-I/M soundings and cloud-drift winds systems are in progress. The initial "Day-1" sounding and wind products to be produced on a combined IBM4381/RISC hardware system from GOES-I/M include vertical temperature and moisture profiles and cloud-drift wind estimates for input to the National Meteorological Center's (NMC) regional numerical forecast models, derived product images of total precipitable water and lifted index for use by the National Hurricane Center (NHC) and the National Severe Storms Forecast Center (NSSFC), and cloud height and amount information above 12,000 feet to supplement observations from the National Weather Service's Automated Surface Observing System (ASOS). In addition, the vertical temperature and moisture profiles are to be used to produce gradient wind information for use by the NMC numerical forecast models and tropical storm monitoring by the NHC. Plans also include the use of METEOSAT-3 data for test and evaluation of the science algorithms and software to be used in producing GOES-I/M cloud-drift wind measurements. All development and implementation activities are on schedule, with an operational METEOSAT-3 winds system to be in place in early 1993, and an operational GOES-I/M soundings and cloud-drift winds system in implemented by early 1994.

GOES I-M SOFTWARE DEVELOPMENT (Hughes)

The software development for the Level-1 Archive and Retrieval system (3-hourly "Synoptic" archive), the Histogram database (for the Climate Analysis Center precipitation estimates) and the Target Matchup database (for calibration monitoring) has been completed.

GLOBAL CO_2 WINDS (Matson)

The NESDIS automated (auto) GOES-7 CO2 winds operation became operational in March 1992. The NOAA National Meteorological Center requested this new operational product because it improved their model output. The operation utilizes four Multi-Spectral Images (MSI) and three infrared (IR) images a half hour apart with one of the image times also containing a carbon dioxide channel image. The CO2 channel imagery is used along with the surface observation data height (Z), temperature (T) and dewpoint (TD), and the forecast model data (Z,T and TD) to generate a height assignment for every potential wind vector. These heights are called targets which are utilized by the three IR images along with the forecast model data (wind (U,V components)) to generate vectors at the target positions. After the vectors are generated, the autoeditor begins editing by deletion and modification of heights to quality control the wind data. When these tasks are completed, the meteorologist is able to begin quality controlling the wind vectors (editing) by manually inspecting all of the data along with plotted contours of streamlines and other forecast model information. This quality controlled data is then sent to the NMC models, placed on the GTS into the SATOB file and saved to the NESDIS archive.

DMSP SATELLITE TEMPERATURE PROFILES (Taylor)

Work continued on the development of a physical retrieval technique to replace the statistical regression method used in the current DMSP SSM/T Operational Sounding processing. Science development for the temperature retrievals over ocean have been baselined and work has begun on incorporating the SSM/I data for retrievals over land. Work has also begun on design of the operational physical retrieval system to process on the NESDIS CEMSCS. In addition to the physical retrieval development, evaluation of the NOAA-KLM Radiosonde Match Subsystem, proposed for the AMSU-A processing sounding system, continues with DMSP data for proof-of-concept and possible implementation. Upgrades to the retrieval system occurred in the areas of dynamic updating of the retrieval ice field using SSM/I data and quality monitoring using a Stability Departure index (comparison against the NMC models). Due to NWS processing requirements efforts began for transfer of all DMSP (and NESDIS) processing from the HDS to the CEMSCS mainframe. Work continued in the areas of quality control and dynamic calibration procedures.

Development efforts began for the processing of data from the first SSM/T-2 Moisture Profiler launched on Nov 28, 1991. The DMSP Sounding System will soon include a total of 19 microwave channels from the SSM/T, SSM/I, and SSM/T-2 instruments.

PART IV System for satellite applications in operational use in 1991

GOES DATA COLLECTION SYSTEM (DCS) (Wydick)

The newly added ground processing equipment, the DCS Automated Processing System (DAPS), has become a valuable part of the Data Collection System (DCS). Monitoring and problem analysis is now routinely accomplished by the DCS Coordinator located in the World Weather Building, Camp Springs, Maryland. He is able to identity a defective Data Collection Platform (DCP) and quickly notify the owner for resolution of the difficulty. The DAPS dial-in service has been expanded to include dissemination of data at 9600 bits/second. This expanded service enables users outside of the United States to retrieve their data with increased efficiency then they could with the former 1200 and 2400 bps service.

GOES WEATHER FACSIMILE (WEFAX) (Wydick)

METEOSAT (M-3) has been moved to 50 degrees west as a standby alternative for GOES-7 imaging function. M-3 will be moved westward, if GOES-7 fails, to perform the otherwise lost United States image coverage. Meanwhile M-3 WEFAX will be available. An M-3 WEFAX schedule has been posted on the NOAA\National Environmental Satellite, Data, and Information Service (NESDIS) Electronic

Bulletin Board and has been distributed to WEFAX receiving stations. M-3 covers the Continental United States and South America.

Improved WEFAX quality control features have been added to the system. Real-time signal monitoring of the transmission circuits is now operational. This addition has minimized transmission losses due to signal degradation of signal interruptions.

CoastWatch PROGRAM WORKSTATIONS (Matson)

Five NESDIS-developed Interactive Digital Image Display and Analysis Systems (IDIDAS) were installed at Coastwatch sites at the NOAA Pacific Marine Environmental Laboratory, Seattle Washington; the NOAA National Marine Fisheries Service Southwest Fisheries Center, La Jolla, California; the NOAA National Weather Service National Hurricane Center, Miami, Florida; and the National Marine Fisheries Service Beaufort Laboratory, Beaufort, North Carolina. These low cost PC-based workstations are being used to support NOAA's Coastal Ocean Program in the display and analysis of NOAA satellite data using software developed and supported by NESDIS.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

GOES I-M STATUS AND OUTLOOK (McGunigal)

The GOES I spacecraft is projected for launch in the spring of 1994. The spacecraft "bus" with the "pathfinder" instruments, S/N002 imager and sounder, is undergoing qualification testing at Space Systems/Loral. This work will be completed later this year and the spacecraft will be placed in storage until the flight instruments are delivered. The imager and sounder instrument development activity at ITT remains on the critical path to launch.

The assembly of the first flight instruments is complete and they are currently in qualification testing. Analysis of data taken to date indicates that the instrument performance substantially exceeds the earlier units. The GOES I-M ground system has been installed at the NESDIS facilities and will be ready to support system checkout and operations when GOES I is launched. The spacecraft will be launched by an Atlas/Centaur vehicle.

GOES DATA COLLECTION PLATFORMS (DCP's) (Wydick)

The project to develop specifications and certifications for higher data rate DCP's has progressed. The high data rate project will provide the option for an increase from the current 100 bits per second (bps) to 300 and 1200 bps. The 100 bps service will be maintained for the convenience of DCP owners who do not require faster rates. Studies leading to the technical definitions required for the procurement to proceed have been completed. The procurement action for final system development is in process at NESDIS. It is planned to initiate operation of the high data rate options in 1993.

PART VI Validation and verification of satellite data and derived products used in operations

SSM/I VALIDATION (Alishouse, Wilkerson)

For wind speed validation, 19 NOAA moored buoys were used for the in-situ wind speed observations. Measurements from these buoys, when compared with the SSM/I-derived wind speeds, revealed that the launch version of the wind speed algorithm produced data with severe bias and scaling problems. In addition, for global coverage, retrievals required using nine separate versions of the algorithms, each dependent on a particular latitude and season.

To correct this deficiency a single version algorithm was developed based on extensive satellite/buoy wind speed comparisons. This refined algorithm met the design accuracy specification of + 2 m/s, globally, over the range 3 m/s - 25 m/s under rain-free conditions. This algorithm also defined appropriate accuracy figures for wind speed retrievals in the presence of rain with provision for three levels of precipitation intensity. This enhancement permitted wind retrievals of lesser accuracy to be made in ocean areas of rainfall which occur about 15% of the time.

An evaluation of SSM/I data (without 85 GHz channels) for detecting and depicting snow and ice cover was started in November 1990, using the operational Northern Hemisphere snow cover analysis (based on visible POES, GOES, and METEOSAT imagery) as ground truth. Systematic errors over desert areas, high plateaus, and coastal zones have been identified. Temporal inconsistencies will also be examined during the evaluation.

PART VII Other items (references, publications and names of scientists in charge, etc.)

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FEDERAL REPUBLIC OF YUGOSLAVIA

Federal Hydrometeorological Institute

PART I A brief summary of major highlights of research applications and operational changes

1.1 An APT/WEFAX-type receiving system was installed in Federal Hydrometeorological Institute (FHMI), in Belgrade, in 1991.

1.2 Applications of VIS and IR (and WV) imagery received from METEOSAT (and occasionally from polar-orbiters) are concentrated mainly on synoptic analysis and forecasting.

PART II A description of major research and development in the applications of satellite data, derived products and services

2.1 No research work has so far been performed in our Institute.

2.2 As to the development work, after the installation of the SKYCEIVER SILVER receiving station (in 1991), the following has been done:

- a training course on satellite imagery interpretation, with slides (based on NOAA/NESDIS 1.A.1 script-slide program "Polar-Orbiter Satellite Imagery Interpretation", 1988, as well as on "Atlas of METEOSAT imagery", ESA SP 1030, 1981, and WMO No 333, Technical Note 124, 1973) was held for weather forecasters, in our Institute;

- "*Manual on Satellite Imagery Interpretation*" (based on the above mentioned NOAA/NESDIS publication) has been issued (in our language) and distributed to all weather services having satellite receiving stations in Yugoslavia.

PART III A description of techniques development and applications of satellite data, derived products and services

3.1 Currently, software upgrading for the present SKYCEIVER SILVER receiving system is under consideration, in cooperation with specialists from TECNAVIA Company. Software modification concerns mainly the cut of the formats of METEOSAT images, improvement of geographic overlay, as well as some changes of the reception program.

3.2 Application of VIS and IR imagery is concentrated mainly on synoptic analysis and forecasting.

3.3 In Weather Forecast Division of FHMI METEOSAT VIS and IR images are regularly received in near real time.
NOAA (METEOR) images are, at the moment, occasionally received (manually).

3.4 The everyday use of VIS and IR images contributes to the improvement of the analyses of current weather situations and short range forecasts as well as some severe weather warnings. This includes mainly the detection of major weather systems like mid latitude depressions with associated frontal systems, relatively small-scale features like squall-lines and thunderstorms with Cb-s, then fog and jet streams and rough qualitative estimation of their intensity, development and movement.

PART IV A brief description of system for satellite applications in current operational use

4.1 Hardware

In FHMI in Belgrade a simple APT/WEFAX-type of satellite receiving system was installed during past year.
It is SKYCEIVER SILVER ground receiving station produced by Swiss company TECNAVIA from Lugano-Agno. It consists of the following:

- 2 m diameter parabolic antenna (with S-band down converter)

- fixed omnidirectional APT/VHF antenna

- multichannel synthesized receiver for:
  S-band (1691, 1694.5 MHz) WEFAX and
  VHF-band (136-138 MHz) APT

- dedicated microprocessor (totally solid state) with 16 MByte levels) mass storage capacity, storing 64 images in two loops

- RGB color 14" video monitor (700 lines resolution)

4.2 Software

Software consists of programs for the following:

- preprogramable automatic reception of METEOSAT (WEFAX) or NOAA (APT) images in two independent loops

- interactive postprocessing of the images in black and white, 16 colours and colours bit slicing

- zoom by two, either animated or roaming fixed

- animation of images at variable speed

- alphanumeric annotations and met. symbols (superimposed on the image)

- overlay of political borders with position and names of cities

The system was put into operation in mid 1991, in Weather Forecast Division of FHMI.

4.3 Archiving

Program for transmission (through RS232 interface) of the received IR METEOSAT image data to host computer (MicroVAX III, CONVEX 220) has been made. The images stored in the archive are of reduced resolution (256-256) due to restricted transmission speed and memory capacity available on the host computer.

PART V Plans for future operational systems for satellite applications to meteorology and operational hydrology

5.1 Investigation of the possibilites of applications of satellite data to very short range forecasting and severe weather warnings.

5.2 The inclusion in MDD system is under consideration.

PART VI Validation and verification of satellite data and derived products used in operations, including performance statistics

N/A

PART VII Other items (references, publications and the names of scientists in charge, etc.)

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